Soft-Shell Clam Survey of the Annapolis Basin, Nova Scotia - 1983

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by

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CONTENTS

List of tables iv

List of figures iv

Abstract/Résumé vii

Introduction 1

Materials and methods 1
Population surveys 1
Clam sampling 2
Growth rate 3
Standing stock 3

Results 4
Surveyed areas 4
Growth rates 5
Standing stock 5

Discussion 6
Population structure 6
Clam density distribution 6
Standing stock 7

Conclusions 8

Acknowledgements 8

References 9

Appendix: Data used in calculating the relationship between clam length (in millimeters) and total number of clams in one bushel 133

LIST OF TABLES

Table

1. Soft-shell clam landings in the Annapolis Basin area and all of Nova Scotia within the Scotia-Fundy Region from 1976 to 1982. Values are in metric tons round weight. 11

2. Areal coverage of study areas within Annapolis Basin. . . 13

3. Length-at-age data used for grouping clams into recruitment categories. 15

4. Percentage of the surveyed population attributed to three recruitment categories. 17

5. Estimates of soft-shell clam standing stock in areas surveyed. 19

6. Density of soft-shell clams per square meter in both the open and closed areas surveyed. 21

LIST OF FIGURES

Figure

1. Annapolis Basin location within the Scotia-Fundy Region. 23

2. Areas sampled within Annapolis Basin 25

3. Annapolis Basin base map indicating figure distribution. 27

4. Oak Point Area "A" sample distribution 29

5. Ryerson Brook Area "A" sample distribution 31

6. Upper Clements Area "A" sample distribution 33

7. Woodland Brook Area "A" sample distribution 35

8. Allains Creek Area "A" sample distribution 37

9. Annapolis Royal Area "A" sample distribution 39

10. Port Royal Area "B1" sample distribution 41

11. Kennedy Brook Area "B1"/"B2" sample distribution 43

12. Granville Beach Area "B2" sample distribution 45

13. Worcester Brook Area "B2" sample distribution 47

Figure

14. Granville Ferry Area "B2" sample distribution 49

15. Thorne Cove sample distribution 51

16. Size frequency distribution - Area "A" 53

17. Size frequency distribution - Area "B1" 55

18. Size frequency distribution - Area "B2" 57

19. Size frequency distribution - Thorne Cove 59

20. Oak Point Area "A" isopleths of clam density distribution - early recruits 61

21. Oak Point Area "A" isopleths of clam density distribution - early pre-recruits 63

22. Oak Point Area "A" isopleths of clam density distribution - recruits 65

23. Ryerson Brook Area "A" isopleths of clam density distribution - early recruits 67

24. Ryerson Brook Area "A" isopleths of clam density distribution - pre-recruits. 69

25. Ryerson Brook Area "A" isopleths of clam density distribution - recruits. 71

26. Upper Clements Area "A" isopleths of clam density distribution - early recruits. 73

27. Upper Clements Area "A" isopleths of clam density distribution - pre-recruits. 75

28. Upper Clements Area "A" isopleths of clam density distribution - recruits. 77

29. Woodland Brook Area "A" isopleths of clam density distribution - early recruits. 79

30. Woodland Brook Area "A" isopleths of clam density distribution - pre-recruits. 81

31. Woodland Brook Area "A" isopleths of clam density distribution - recruits. 83

32. Allains Creek Area "A" isopleths of clam density distribution - early recruits. 85

Figure

33. Allains Creek Area "A" isopleths of clam density distribution - pre-recruits 87

34. Allains Creek Area "A" isopleths of clam density distribution - recruits 89

35. Annapolis Royal Area "A" isopleths of clam density distribution - early recruits 91

36. Annapolis Royal Area "A" isopleths of clam density distribution - pre-recruits 93

37. Annapolis Royal Area "A" isopleths of clam density distribution - recruits 95

38. Port Royal Area "B1" isopleths of clam density distribution - early recruits 97

39. Port Royal Area "B1" isopleths of clam density distribution - pre-recruits 99

40. Port Royal Area "B1" isopleths of clam density distribution - recruits 101

41. Kennedy Brook Area "B1"/B2" isopleths of clam density distribution - early recruits 103

42. Kennedy Brook Area "B1"/"B2" isopleths of clam density distribution - pre-recruits 105

43. Kennedy Brook Area "B1"/"B2" isopleths of clam density distribution - recruits 107

44. Granville Beach Area "B2" isopleths of clam density distribution - early recruits 109

45. Granville Beach Area "B2" isopleths of clam density distribution - pre-recruits 111

46. Granville Beach Area "B2" isopleths of clam density distribution - recruits 113

47. Worcester Brook Area "B2" isopleths of clam density distribution - early recruits 115

48. Worcester Brook Area "B2" isopleths of clam density distribution - pre-recruits 117

49. Worcester Brook Area "B2" isopleths of clam density distribution - recruits 119

Figure

50. Granville Ferry "B2" isopleths of clam density distribution - early recruits 121

51. Granville Ferry Area "B2" isopleths of clam density distribution - pre-recruits 123

52. Granville Ferry Area "B2" isopleths of clam density distribution - recruits 125

53. Thorne Cove isopleths of clam density distribution - early-recruits 127

54. Thorne Cove isopleths of clam density distribution - pre-recruits 129

55. Thorne Cove isopleths of clam density distribution - recruits 131

ABSTRACT

Angus, R.B., C.M. Hawkins, P. Woo, and B. Mullen. 1985. Soft-shell clam survey of the Annapolis Basin, Nova Scotia - 1983. Can. MS Rep. Fish. Aquat. Sci. 1807: viii + 133 p.

Assessements of soft-shell clam (Mya arenaria) stocks were carried out in two "closed" and one "open" shellfish-growing area in the Annapolis Basin, N.S., area of the Scotia-Fundy Region. In 1983, standing stocks of pre-recruits (43-50 mm shell length) in closed areas ranged from 4.8-12.9 bu/ha. In the open area, the standing stock of pre-recruits was 4.1 bu/ha. Standing stock of recruits (51 mm+ shell length) in the closed areas ranged from 11.4-31.2 bu/ha and in the open area 15.0 bu/ha. Growth rate analysis indicated that soft-shell clams reach market size of 51 mm in length in approximately 7.5 yr. Isopleths of clam density are presented for each study area and indicate little spatial overlap in the distribution of clams within different recruitment categories.

RÉSUMÉ

Angus, R.B., C.M. Hawkins, P. Woo, and B. Mullen. 1985. Soft-shell clam survey of the Annapolis Basin, Nova Scotia - 1983. Can. MS Rep. Fish. Aquat. Sci. 1807: viii + 133 p.

On a évalué les stocks de myes (Mya arenaria) dans deux gisements "fermés" et un gisement "ouvert" du bassin Annapolis, dans la région Scotia-Fundy. En 1983, la biomasse des

pré-recrues (coquille de 43 à 50 mm de longueur) allait de 4,8 à 12,9 bo/ha dans les gisements fermés. Dans le gisement ouvert elle était de 4,1 bo/ha. Par ailleurs, la biomasse des recrues (coquille de 51 mm et plus de longueur) allait de 11,4 à 31,2 bo/ha dans les gisements fermés et elle était de 15,0 bo/ha dans le gisement ouvert. L'analyse de taux de croissance a révélé qu'il faut compter environ 7,5 ans avant que la mye n'atteigne la longueur marchande de 51 mm. L'examen des isolignes de population de chaque gisement étudié révèle qu'il y a peu de chevauchement entre les différentes catégories de recrutement.

INTRODUCTION

The Annapolis Basin, located on the southwest shore of Nova Scotia (Fig. 1), is an important soft-shell clam, Mya arenaria, producing area of Nova Scotia. Historically, the area has consistently produced over 30% of the clams harvested from the Scotia-Fundy Region. Over the past 7 yr alone, these landings have accounted for 53-68% of all soft-shell clam landings in Nova Scotia (Table 1). However, the values presented in Table 1 reflect only recorded landings at licensed clam-producing plants and do not include unreported landings from part-time clam diggers harvesting for personal consumption or for private sale, i.e. to the restaurant trade in the whole province. These latter landings have been estimated to exceed the reported landings (hence clam production) by about 50-75% (P. Outhouse, pers. comm.[1]).

The Annapolis Basin contains about 1,960 ha of clam flats. About 50% of these clam-producing areas are "closed" to commercial and recreational fishing due to bacteriological contamination (Health and Welfare 1967). Recent water quality surveys in the upper reaches of the Annapolis River Basin indicated that the area now has acceptable water quality to allow commercial and recreational fishing in a section of the Basin (Environmental Protection Service 1984). Since the shellfish- growing area to be opened in 1984 has been closed to fishing for 17 yr, the Fisheries Research Branch, of the Department of Fisheries and Oceans, Scotia-Fundy Region, undertook a project to assess the standing stock of clams in that area. In addition, one "open" shellfish-growing area within the Basin ("open": waters of acceptable bacteriological quality) was surveyed to evaluate its clam resources, for comparative purposes.

MATERIALS AND METHODS

POPULATION SURVEYS

Sampling was undertaken in one open area, Thorne Cove, and three sites in the Annapolis River Basin closed area (Fig. 2). These sites were selected according to the ease of access to the clam flats and were designated as: Area "A" - the south side of the Annapolis River from Oak Point to Allain River; and Areas "B1" and "B2" - the north side of the river from Port Royal to Granville Ferry. Thorne Cove, the open area, is located on the north side of the Annapolis Basin (Fig. 2).

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In Areas "A" and "B1" samples were collected at 20 m intervals along parallel lines 20 m apart aligned perpendicular to a baseline positioned along the shoreline. The baseline was set arbitrarily at the first appearance of live clams in the sediment seaward of the shore. Transect lines were extended from the baseline to a point where sediments were completely covered with water at mean low tide or until they reached extremely soft muds where no clams were found. In Area "B2" sampling was carried out at 20 m intervals along parallel transects perpendicular to a baseline at 200 m intervals. In Thorne Cove, samples were collected at 50 m intervals along parallel transect lines 50 m apart. Sampling intensity for Area "B2" and Thorne Cove was less than for the other areas. This lowering of sampling intensity was necessary in order that the survey of the entire region could be completed with the limited number of field personnel and within the time available. The total number of hectares surveyed at each study area was calculated with a Hewlett-Packard (Model 9874A) digitizer from 1:10,000 topographic maps.

CLAM SAMPLING

Several researchers noted that soft-shell clams may burrow to a depth of 20 cm (Medcof 1950; Robert 1981; Witherspoon 1982; 1983). Consequently, we selected 20 cm as the sampling depth in our 0.1 m^2 quadrat samples. To ensure that small clams (<6 mm shell length) were effectively sampled, we initially removed the top 5 cm with a garden trowel, (cf. Moller and Rosenberg, 1983), bagged, and labeled this subsample for processing in the laboratory. The remaining sample (to 20 cm) was removed with a square-nose shovel and immediately washed through a 18 mm then 6 mm mesh plastic sieve. All soft-shell clams retained by the field sieving process were bagged, labeled, and returned to the laboratory for further analysis. At the laboratory, sediment containing clams from the top 5 cm was washed through a 1 mm sieve and all clams retained were removed for measurement. Clams were measured along their longest axis with the aid of a modified fish measuring board or vernier calipers and grouped into 13 predetermined shell length classes. Each length class represented the approximate range in lengths that a clam of a specific age could occupy. This range of lengths-at-age was determined from a von Bertalanffy growth equation (see below).

Since we were interested in the abundance and distribution of clams that are recruited in the fishery, the 13 ranges of length-at-age were then grouped into three recruitment categories designated as: early recruits (0-42 mm), pre-recruits (43-50 mm), and recruits (51 mm+). Clam distribution and abundance (clams/m^2) within the above

length categories were determined for all survey stations. The percentage composition attributed to each of the recruitment categories was obtained from frequency distributions established for each sample. Using these values and the estimated total number of individuals in a known sampling area, the density of clams of each recruitment category was established for all surveyed areas. The density of clams within each recruitment category at each station was then plotted for each study area. Subsequently, density isopleths were drawn by eye to delineate areas of similar concentrations.

GROWTH RATE

Newcombe (1936) has shown that soft-shell clams show marked seasonal variations in metabolic activity which allow estimation of annual growth from shell reading. The distance between pronounced rings demarcate growth which occurs in one growing season. Growth rings are best measured as shell widths, and shell widths are subsequently converted to shell lengths prior to fitting the data to a von Bertalanffy-type growth equation (Robert 1981). The von Bertalanffy growth equation established for the Annapolis Basin data was based on measurements from 210 individuals ranging in length from approximately 5 mm to 75 mm. All length and width measurements were made on clean shells with vernier calipers read to the nearest 0.1 mm.

STANDING STOCK

Prior to assessing the standing stock of live clams in each of the study areas a mathematical relationship between clam shell length and number per bushel was established. For this we counted the number of clams in each of seven length groups that filled a bushel box (43 cm x 31.5 cm x 27.5 cm) or known part thereof. The first length group was from 0-20 mm; the remaining six were at 10 mm intervals. The logarithm of the number of clams per bushel in each of the seven length groups was then regressed against the midpoint of the length group. The resulting equation (Appendix) permitted the determination of the number of live clams of any length to fill a bushel.

The standing stock (round weight) in terms of bushels per hectare was then determined for the pre-recruit and recruited length categories in each of the study areas. Standing stock expressed in terms of kilograms per hectare was subsequently determined by multiplying the bushel per hectare figure times 27.3 kg per bushel (Hawkins and Rowell 1984).

RESULTS

SURVEYED AREAS

In this study the surveyed area (Fig. 2 and 3) refers to the estimated total area of the clam flat while the sampled area is that portion of the surveyed area covered by sampling stations. The surveyed closed areas ("A," "B1," and "B2") totaled 188.15 ha with 132.43 ha sampled (70%) (Table 2). In Thorne Cove, the only open area examined, 87.5 ha were surveyed while 55.5 ha were sampled (63%). In combining open and closed areas, a total of 275.65 ha were surveyed and 187.93 sampled (68%). A total of 338 transects encompassing 1,697 stations were established within Area "A." This constituted a sampling intensity of 0.025% over the sampling area of 72.11 ha. Distributions of the sampling stations and transects for Area "A" are shown in Figures 4 to 9. The substrate in this area appeared homogeneous along the shoreline. There was a fringe of gravel at the high tide level, a firm mud intertidal section, and a soft viscous silt overburden at the low tide level.

Area "B1" extends from the closure line at the western end of the Annapolis River, 1,760 m eastward (Fig. 2 and 3). Samples were collected at a total of 340 stations along 87 transects covering a sampling area of 16.77 ha. Sampling intensity was 0.05% with samples distributed over the area as shown in Figures 10 and 11. The intertidal area was relatively narrow compared with Area "A." The substrate appeared more viscous than in Area "A," but no quantitative analysis was undertaken.

Area "B2" continues 4,000 m eastward from the edge of Area "B1" (Fig. 2). Samples were collected from 44 stations covering 43.55 ha with an intensity of 0.005% (Fig. 11 to 14). Substrate was very similar to that found in Area "B1."

Thorne Cove lies on the northern side of the Annapolis River (Fig. 2 and 3). A total of 58 samples were taken along five transects covering a sampling area of 55.5 ha. Sampling intensity was 0.016%. Positions of the sampling stations are shown in Figure 15. In general, the substrate was similar to that in Area "A."

Length frequency histograms for each area examined are shown in Figures 16 to 19. Area "A" showed a prominent modal peak between the 15 and 22 mm length range, which comprised 46.9% of the total population sampled (Fig. 16). In comparison, Area "B1" exhibited a predominant modal peak within the 30-36 mm length range. This mode contained 37.8% of the sampled population (Fig. 17). Area "B2" and Thorne Cove showed similar modal peaks in the 0-5 mm range. This modal size range accounted for 25.2% of the sampled population in Area "B2"

(Fig. 18), and in Thorne Cove the same modal size range accounted for 22.9% (Fig. 19). The 0-5 mm length range was the most prominant mode in the Thorne Cove frequency distribution.

GROWTH RATES

We selected 51 mm and greater as the length category for recruits. To accommodate a range of lengths for clams that would reach the recruitment category with one additional year of growth, we selected a 8 mm size range covering animals 43-50 mm and designated this range of lengths as a pre-recruit category (column 4, Table 3). Smaller individuals were designated as early recruits. These three categories were then used to further describe the abundance and distribution of clams in the areas surveyed.

A comparison among the areas surveyed and the percentage of the sampled population attributed to each of the three recruitment categories is shown in Table 4. In all areas, early recruits comprised the greatest proportion of the sampled population, with values of pre-recruits and recruits markedly lower. The spatial distribution of each recruitment category is shown for Areas "A," "B1," and "B2" in Figures 20 to 37, 38 to 43, and 44 to 52 respectively and for Thorne Cove in Figures 53 to 55. In general there appears to be little overlap in the pattern of clam density distribution between different recruitment categories.

A von Bertalanffy growth equation of the form:

$$L_t = L_\infty(1-e^{-k\ (t-t_0)})$$

was fitted to length-at-age data and yielded the following values (±95% confidence limits) for the three parameters: L_∞ = 117.91 (±13.01), k = 0.08 (±0.01), and t_0 = 0.46 (±0.18). Evaluation of this equation based on the above parameters indicated that soft-shell clams in the Annapolis Basin reach the market size (length) of about 51 mm (2 inches) in about 7.5 yr (Table 3, column 5).

STANDING STOCK

The standing stock of pre-recruits (43-50 mm) and recruits (51 mm+) for all areas surveyed are expressed in bushels per hectare and kilograms per hectare in Table 5. Area "B1" showed the largest number of pre-recruits (12.9 bu/ha, 353 kg/ha), followed by Areas "A" and "B2" and Thorne Cove respectively. Area "A" exhibited the highest number of recruits (31.2 bu/ha, 849 kg/ha) followed in decreasing order by Area "B1" (15.4 bu/ha, 421 kg/ha), Thorne Cove (15.0 bu/ha, 409 kg/ha), and Area "B2" (11.4 bu/ha, 309 kg/ha).

DISCUSSION

MacLeod and Hill (1973) provide the most recent information on soft-shell clam populations in the Annapolis River Basin area. Their population studies were conducted in closed areas, two of which correspond to Areas "A," "B1," and "B2" examined in the present study. MacLeod and Hill utilized a sampling intensity of 0.002% over all areas and a small sample size to base population estimates: 1,006 clams for the north side of the River and 4,887 clams for the south side of the River. In the present study the sampling intensity in the closed areas was several times greater than that used by MacLeod and Hill and ranged from 0.005% to 0.025%. In addition, our population estimates were based on 54,900 clams for the south side of the River and 2,572 for the north side of the River (Areas "B1" and "B2"). Since these numbers are considerably higher than those used by MacLeod and Hill, it is not surprising that comparisons of standing stock values between the two studies are markedly different and of little value. Also, it has been 10 yr since this area has been surveyed. Consequently, comparisons between populations in our study and those in MacLeod's and Hill's were considered of little value.

POPULATION STRUCTURE

The percentage of the surveyed populations attributed to each recruitment category in both the open and closed areas is shown in Table 4. In all areas the early recruits comprise the major proportion. However, it is interesting to note that both the pre-recruit and recruit categories comprise a higher proportion of the sampled population in the open area, Thorne Cove, than in the closed areas (Table 4). It appears that even under heavy (pers. observation) commercial and recreational fishing pressure soft-shell clams survive to the pre-recruit and recruit length categories much better in the area which is heavily fished than in the areas which are closed and not subject to fishing pressure. It will be interesting to follow any change in population structure in the closed areas once they are opened to recreational and commercial fishing, to see if similar patterns in the population structure develop compared with those presently found in the open, Thorne Cove area.

CLAM DENSITY DISTRIBUTION

The density of soft-shell clams/m^2 in each of the areas surveyed is shown in Table 6. Pre-recruit densities (43-50 mm) in each of the closed areas are higher than in the open area. Only in Area "A" does the density of recruits (51 mm+) exceed that found in the open area, Thorne Cove. The lower densities in the closed Areas "B1" and "B2" may indicate that there is

greater size-selective mortality in these two areas over that which occurs in Area "A" or Thorne Cove. At present, Area "A" supports the highest densities of recruits and Area "B1" the highest densities of pre-recruits/m^2 in comparison to the other areas examined, either open or closed.

Isopleths of clam density distribution for the three recruitment categories provide site-specific information on spatial recruitment patterns. In general, there is little spatial overlap. Early recruits are not found in any great abundance within areas numerically dominated by pre-recruits and recruits.

Although the density isopleths give some indication of patchiness in the spatial distribution of each of the three recruitment categories, they also reflect patterns of growth and survival. The fact that there is little overlap in density distributions indicates that recruitment, growth, and survival may not be uniform over the area examined. Competition for food, space, as well as suitable substrate may be the most important factors influencing the distribution and abundance of clams. Nevertheless, the mapped density distributions of clams over a large area provide the basis to monitor the future impact of fishing on the spatial distribution of clams, as well as survival and changes in population structure.

STANDING STOCK

Standing stock of pre-recruits in each of the three closed areas exceeds the value for the open area when expressed on a bushels per hectare basis (Table 5). Area "B1" exhibited the highest standing stock of pre-recruits with 12.9 bu/ha (353 kg/ha) followed by Area "A" with 8.4 bu/ha (228 kg/ha) and "B2" with 4.8 bu/ha (132 kg/ha). Thorne Cove, the open area, had a standing stock of pre-recruits of 4.1 bu/ha (113 kg/ha). However, it is interesting to note that Area "B2" has only a slightly larger standing stock than the open area, Thorne Cove. This may indicate that Area "B2" is a relatively poor area for growth and survival of soft-shell clams since no legal fishing has occurred in this area for over 10 yr. This low standing stock is also reflected in the recruitment category (see below).

The standing stock of recruits varies by a factor of about 3 over closed areas examined. Area "B2" exhibited the lowest standing stock of recruits, with 11.4 bu/ha (309 kg/ha). In contrast, Area "A" exhibited the highest standing stock of recruits with 31.2 bu/ha (849 kg/ha). Area "B2" with a standing stock of 15.4 bu/ha (421 kg/ha) is similar to that found for the open area, Thorne Cove (15.0 bu/ha, 409 kg/ha). It is interesting to note that Thorne Cove has a relatively high

standing stock of recruits even though it is subjected to heavy commercial and recreational fishing pressure. This may indicate that Thorne Cove is a superior clam-producing area in the Annapolis Basin.

In comparison with other areas in Nova Scotia, the standing stock of soft-shell clams is quite low. Witherspoon (1982; 1983), in studies of the standing stock of soft-shell clams in the eastern and western regions of Nova Scotia, found that standing stock values of market-sized clams ranged from 40-300 bu/ha. In New Brunswick, Robert and Smith (1980) revealed that soft-shell clam populations in Charlotte County (30 mm+) ranged from about 74 to 338 bu/ha. However, these comparisons to the Annapolis Basin data must be viewed with caution because the survey methods differ considerably between researchers.

CONCLUSIONS

1. Growth rate analysis of soft-shell clams in the Annapolis Basin indicates that market-size individuals (51+ mm shell length) is reached in about 7.5 yr.

2. Standing stock of pre-recruits (43 to 50 mm shell length) in the closed areas ranged from 4.8 to 12.9 bu/ha. In the open area, the standing stock of pre-recruits was 4.1 bu/ha.

3. Standing stock of recruits (51+ mm shell length) ranged from 11.4 to 31.2 bu/ha in the closed areas. In Thorne Cove, the open area, the standing stock of recruits was estimated at 15.0 bu/ha.

4. Density distributions indicate that there is little overlap in the distribution of each of the recruitment categories.

5. A linear relationship relating the number of live clams in a bushel and clam shell length in millimeters is presented.

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Table 1. Soft-shell clam landings* in the Annapolis Basin area and all of Nova Scotia within the Scotia-Fundy Region from 1976 to 1982. Values are in metric tons round weight.

Year	Landings		% of Nova Scotia total landings
	Annapolis Basin	Nova Scotia total	
1976	552	945	58
1977	849	1,313	65
1978	903	1,573	57
1979	726	1,279	57
1980	1,458	2,141	68
1981	1,336	2,135	63
1982	1,234	2,366	57

*Statistics Division, Management Services Branch, Department of Fisheries and Oceans, Scotia-Fundy Region, Halifax, N.S. B3J 2S7

Table 2. Areal coverage of study areas within Annapolis Basin.

Location	Surveyed hectares[1]	Sampled hectares[2]
Closed areas:		
Area A	100.65	72.11
Area B1	23.52	16.77
Area B2	63.98	43.55
Total	188.15	132.43
Open area:		
Thorne Cove	87.50	55.50
Overall total (open and closed):	275.65	187.93

[1]Surveyed area refers to the estimated total area of the clam flat.

[2]Sampled area refers to that portion of the surveyed area covered by the sampling program.

Table 3. Length-at-age data used for grouping clams into recruitment categories.

Age (yr)	Length[1] (mm)	Length range[2] (mm)	Length range[3] for recruitment classification	Age range[4] (yr)	Recruitment category
1	4.98	0-5	0-5	1.0	
2	13.67	6-14	6-14	1.1-2.0	
3	21.69	15-22	15-22	2.2-3.0	early
4	29.10	23-29	23-29	3.2-4.0	recruits
5	35.93	30-36	30-36	4.1-5.0	
6	42.24	37-42	37-42	5.2-6.0	
7	48.07	43-48			
8	53.44	49-54	43-50	6.1-7.4	pre-recruits
9	58.40	55-58	51-58	7.5-8.9	
10	62.98	59-63	59-63	9.1-10.0	recruits
11	67.21	64-67	64-67	10.1-11.0	
12	71.11	68-71	68-71	11.1-12.0	
13	74.71	72-74	72-74	12.1-13+	

[1]Predicted from von Bertalanffy growth equation.

[2]Range used for grouping raw field data of clam size.

[3]Range used for grouping into recruitment categories.

[4]Age range predicted from von Bertalanffy growth equation from data in column 4 above.

Table 4. Percentage of the surveyed population attributed to three recruitment categories.

Location	Recruitment category			Total area surveyed (ha)
	Early (0-42 mm)	Pre-recruit (43-50 mm)	Recruit (51 mm+)	
Closed areas:				
"A"	97.5	1.0	1.5	100.65
"B1"	87.7	8.4	3.9	23.52
"B2"	96.6	2.0	1.4	63.98
Open area:				
Thorne Cove	71.9	11.5	16.7	87.5

Table 5. Estimates of soft-shell clam standing stock in areas surveyed.

Recruitment category	Surveyed area							
	Closed						Open	
	"A"		"B1"		"B2"		Thorne Cove	
	bu/ha	kg/ha	bu/ha	kg/ha	bu/ha	kg/ha	bu/ha	kg/ha
Pre-recruits:								
(43-50 mm)	8.4	228	12.9	353	4.8	132	4.1	113
Recruits (mm):								
51-58	10.0	273	4.6	125	0.9	25	5.1	138
59-63	7.2	196	4.3	118	2.8	76	3.9	106
64-67	4.9	134	1.3	35	1.9	51	3.9	107
68-71	5.1	138	0.6	17	2.5	67		
72-74	1.5	41	3.7	102			2.1	58
74+	2.5	67	0.9	24	3.3	90		
Total recruits	31.2	849	15.4	421	11.4	309	15.0	409
Total area	100.65 ha		23.52 ha		63.98 ha		87.50 ha	

Table 6. Density of soft-shell clams per square meter in both the open and closed areas surveyed.

Recruitment category	Closed area			Open area
	"A"	"B1"	"B2"	Thorne Cove
Pre-recruit (43-50 mm)	3.3	5.2	2.1	1.8
Recruit (51+ mm)	4.8	2.4	1.4	2.7
Total	8.1	7.6	3.5	4.5

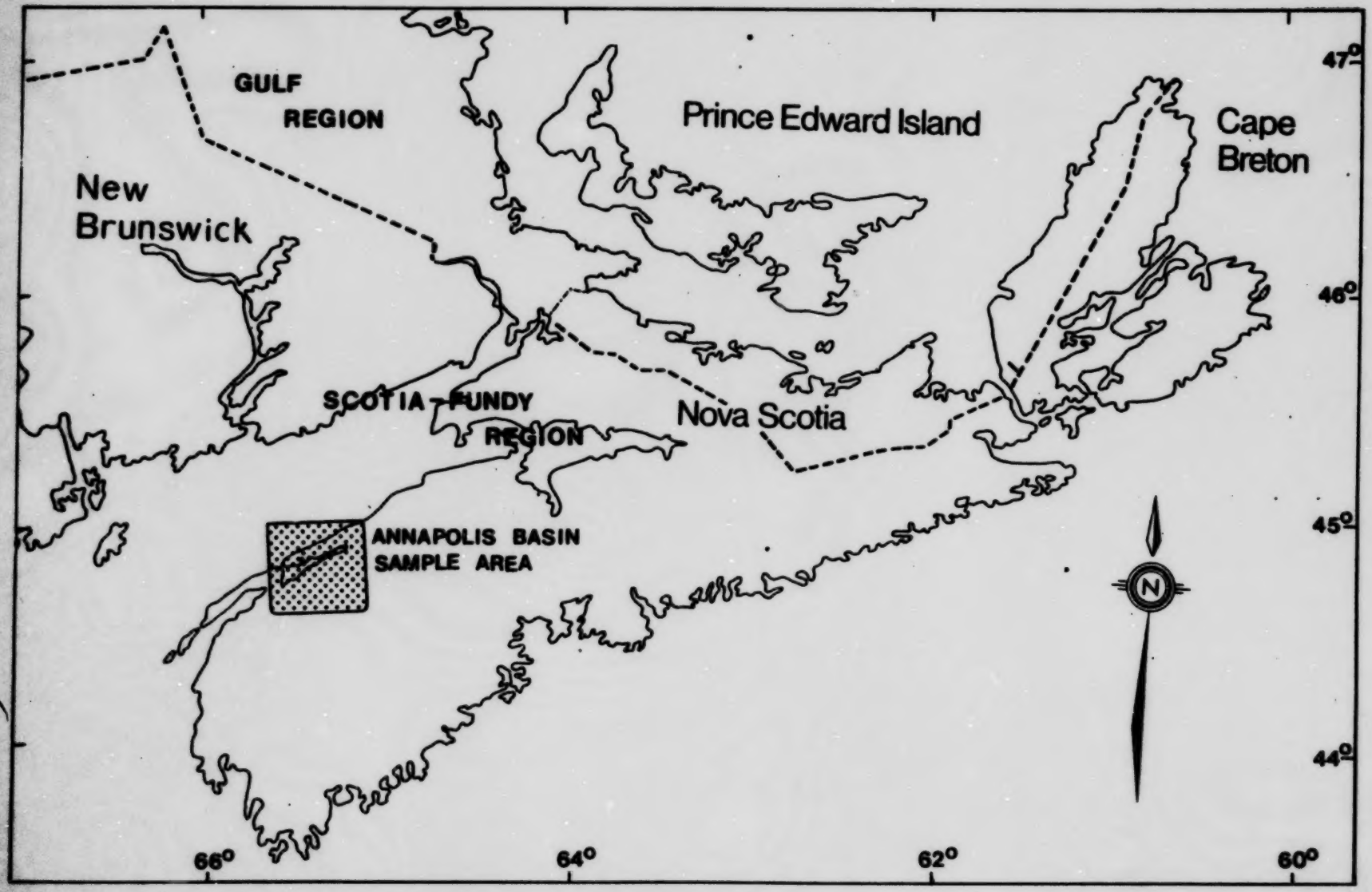


Fig. 1. Annapolis Basin location within the Scotia-Fundy Region.

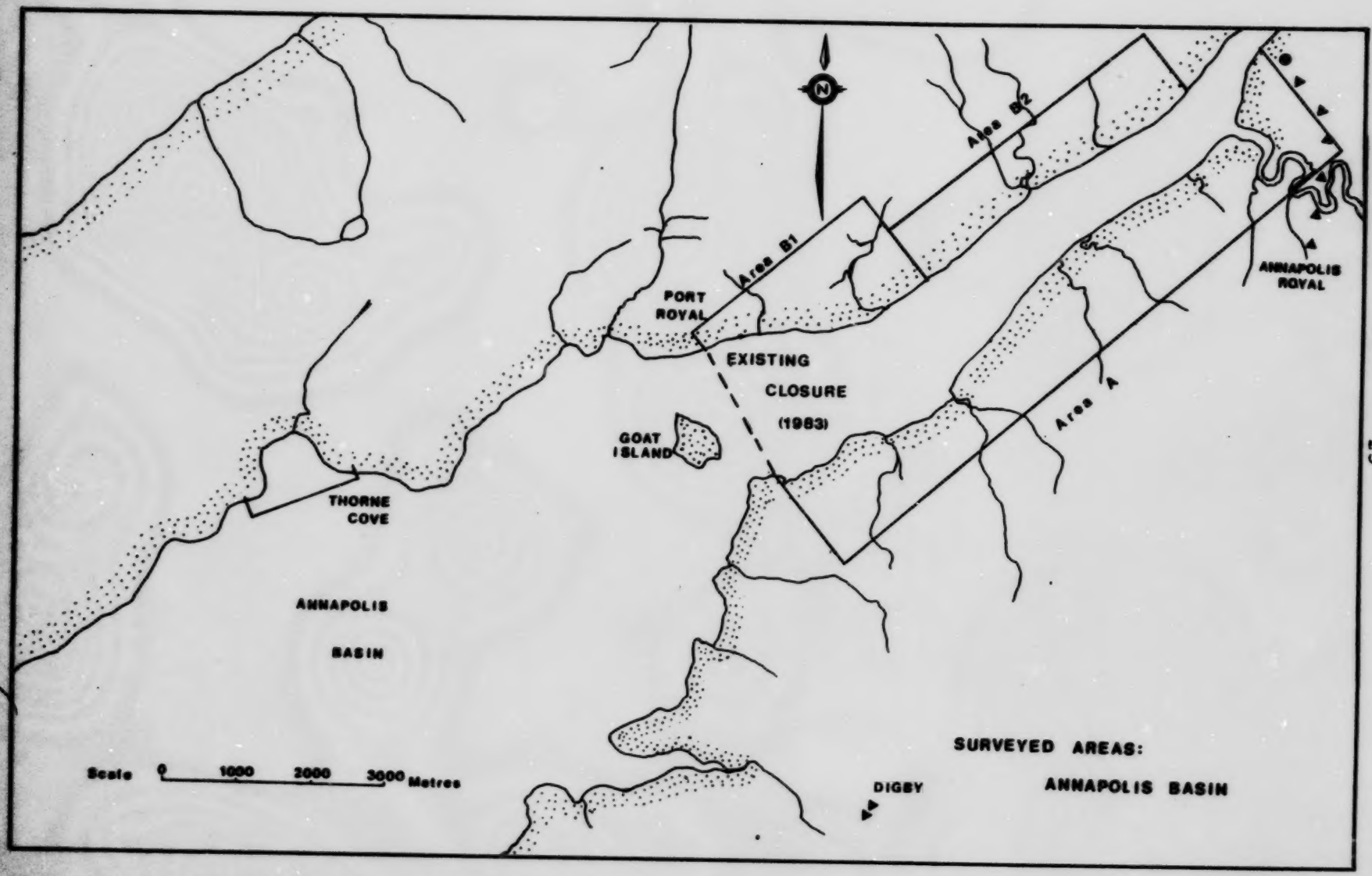


Fig. 2. Areas sampled within Annapolis Basin.

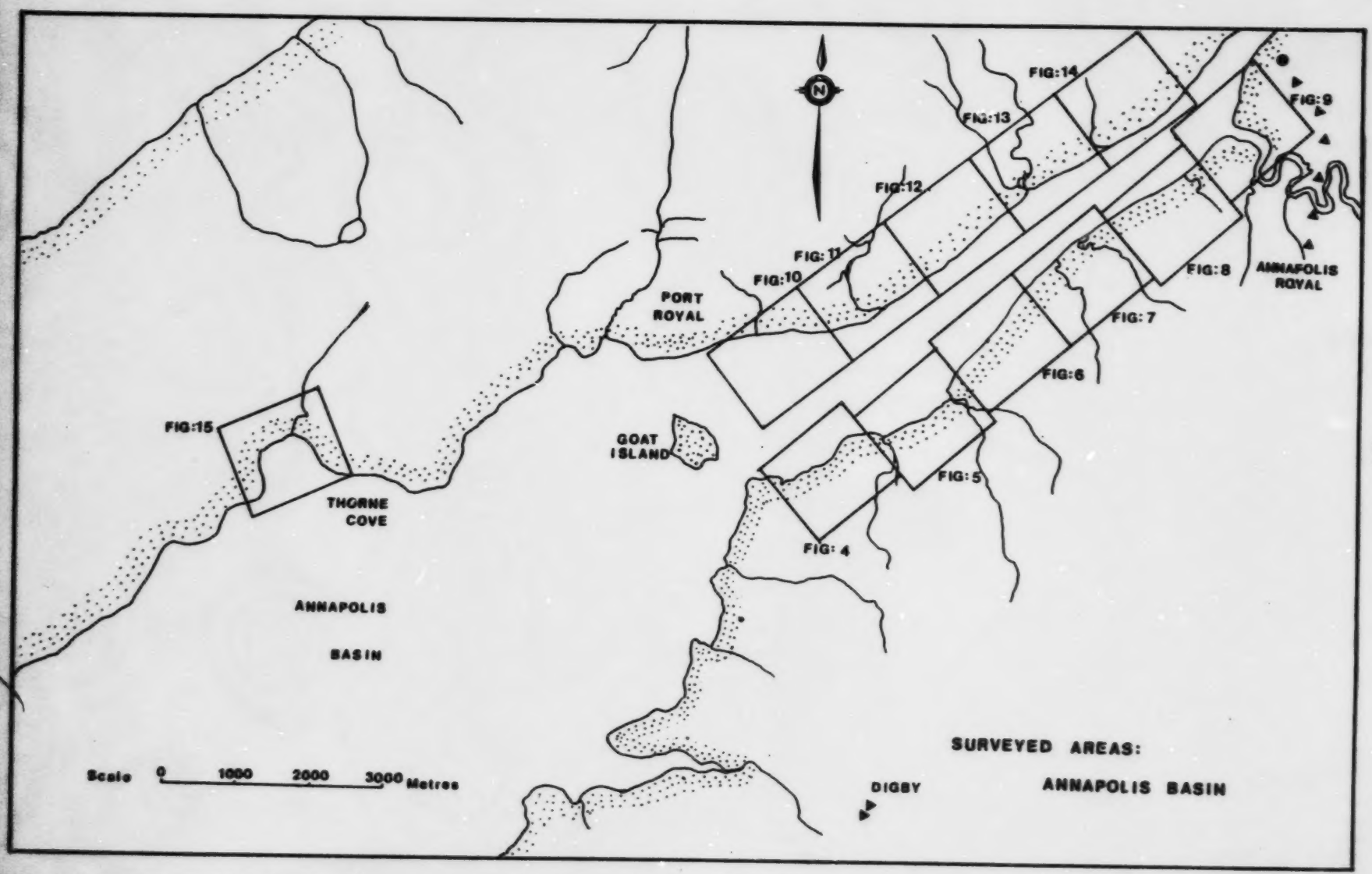


Fig. 3. Annapolis Basin base map indicating figure distribution.

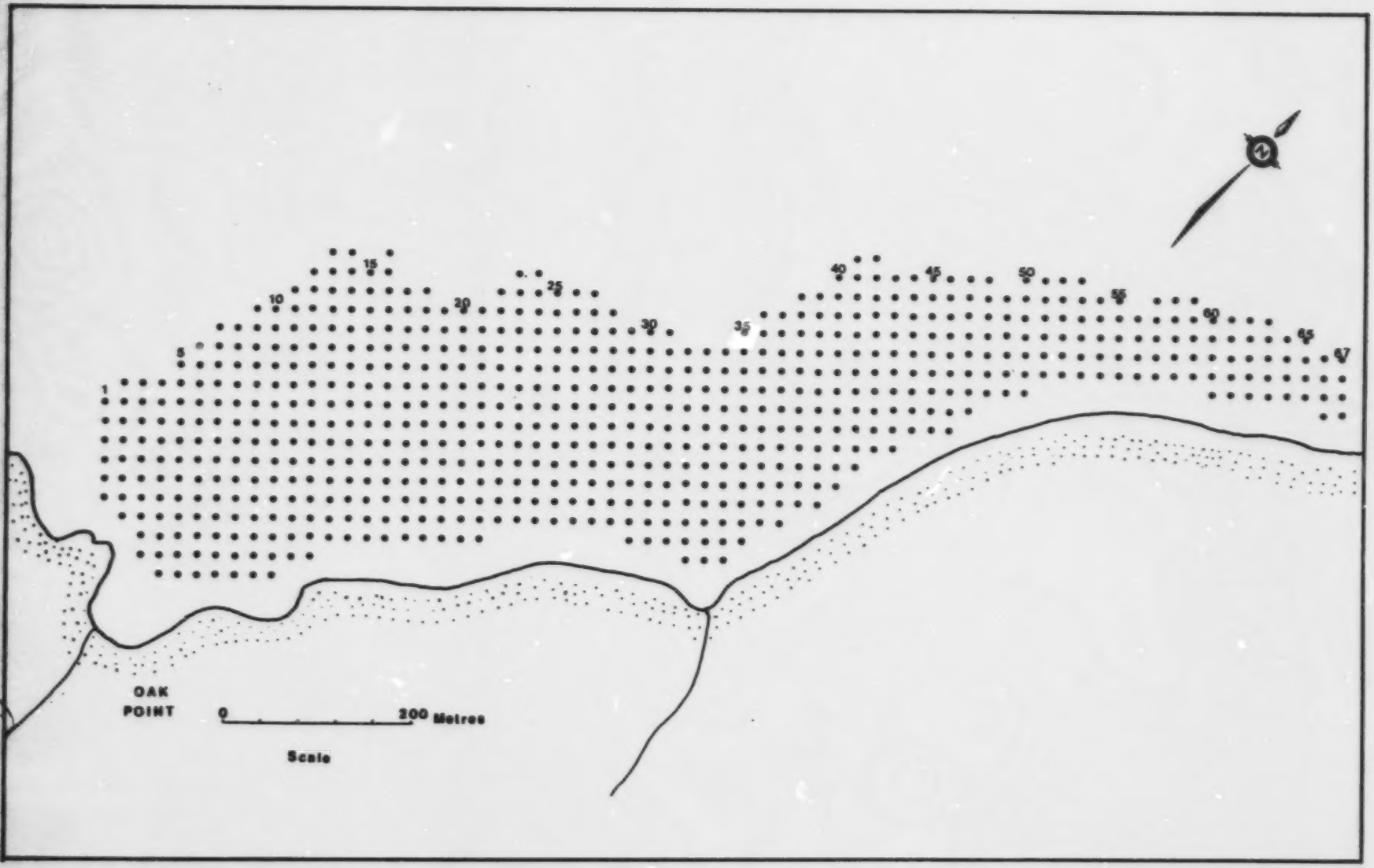


Fig. 4. Oak Point Area "A" sample distribution.

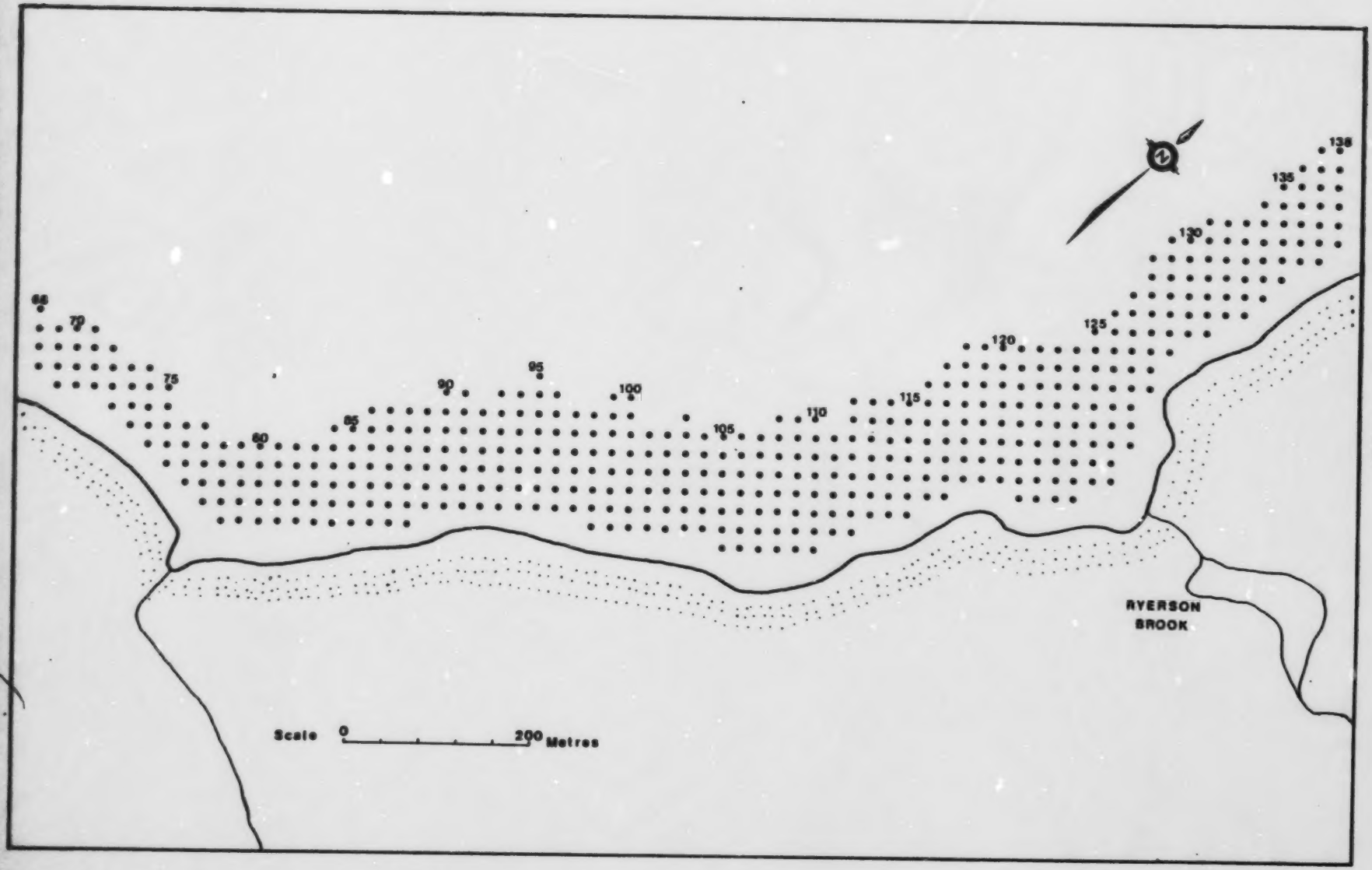
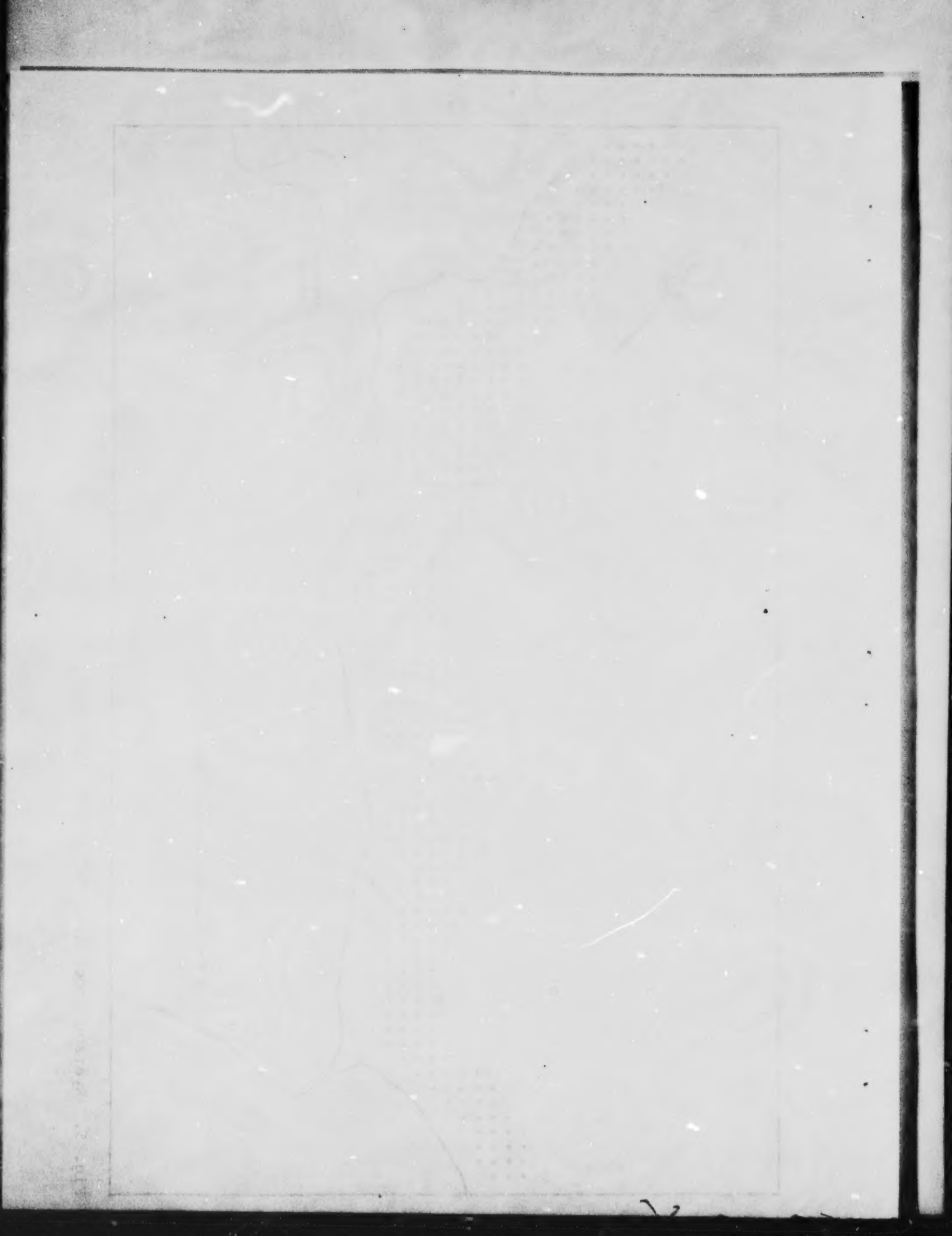


Fig. 5. Ryerson Brook Area "A" sample distribution.



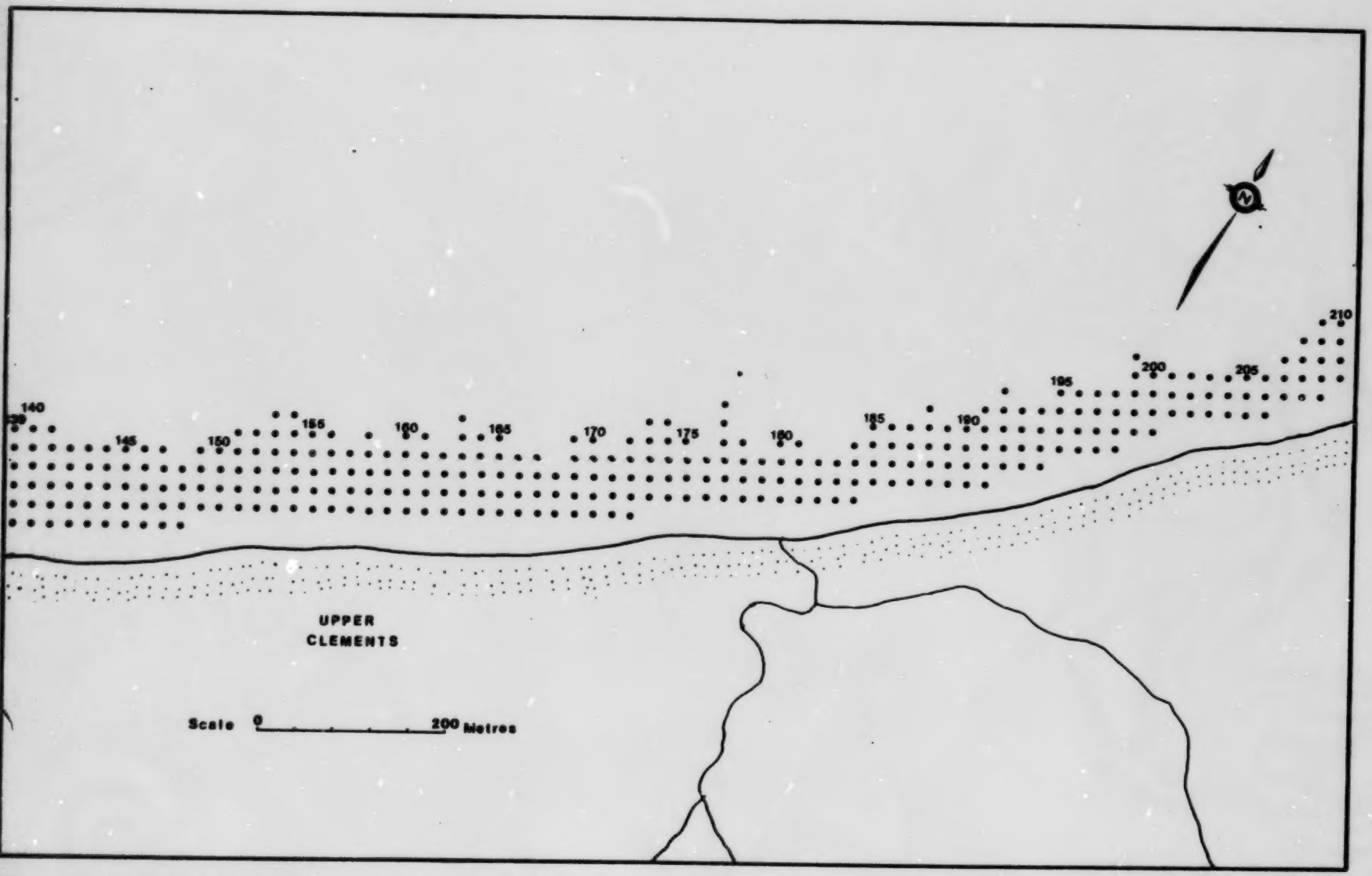


Fig. 6. Upper Clements Area "A" sample distribution.

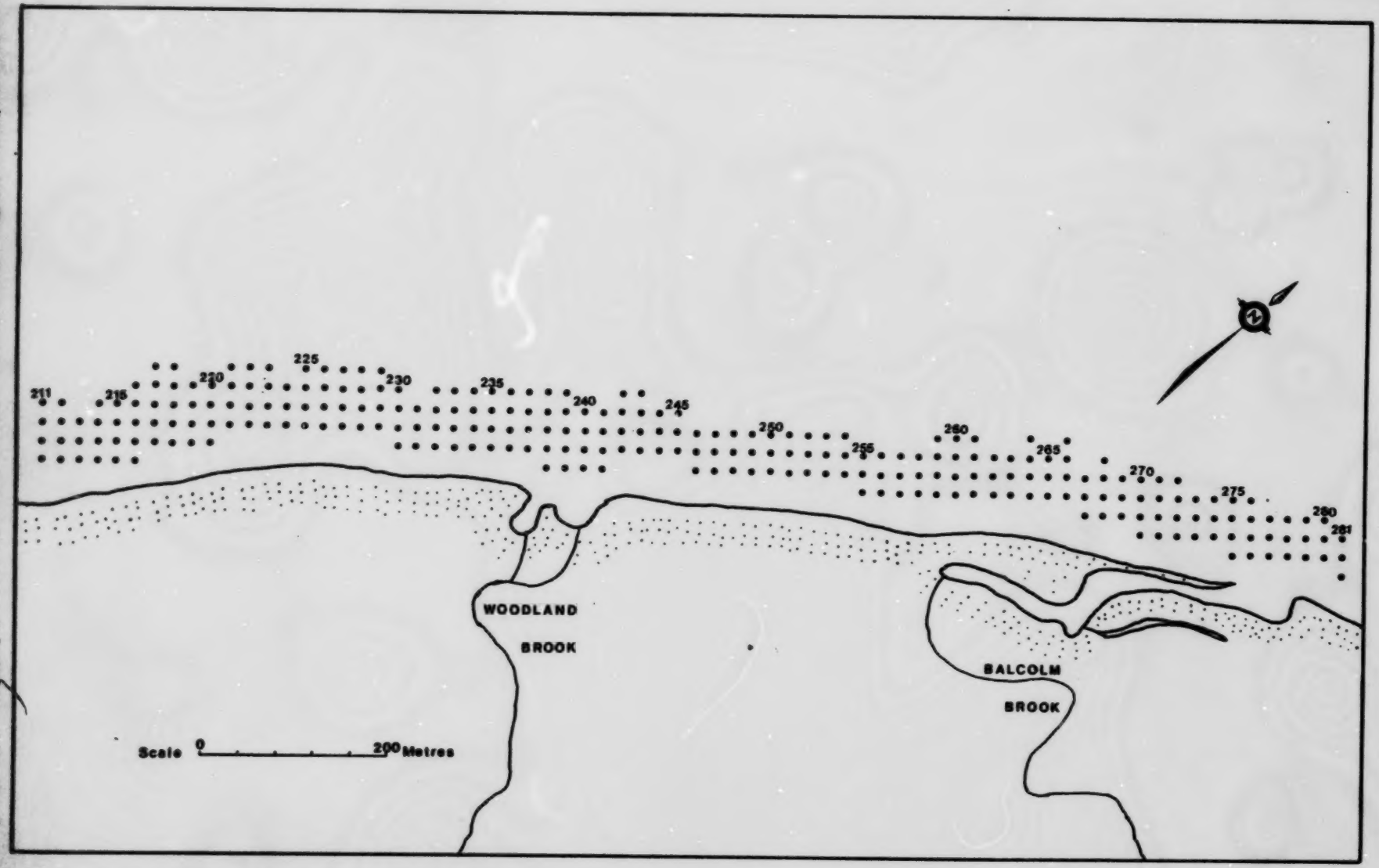


Fig. 7. Woodland Brook Area "A" sample distribution.

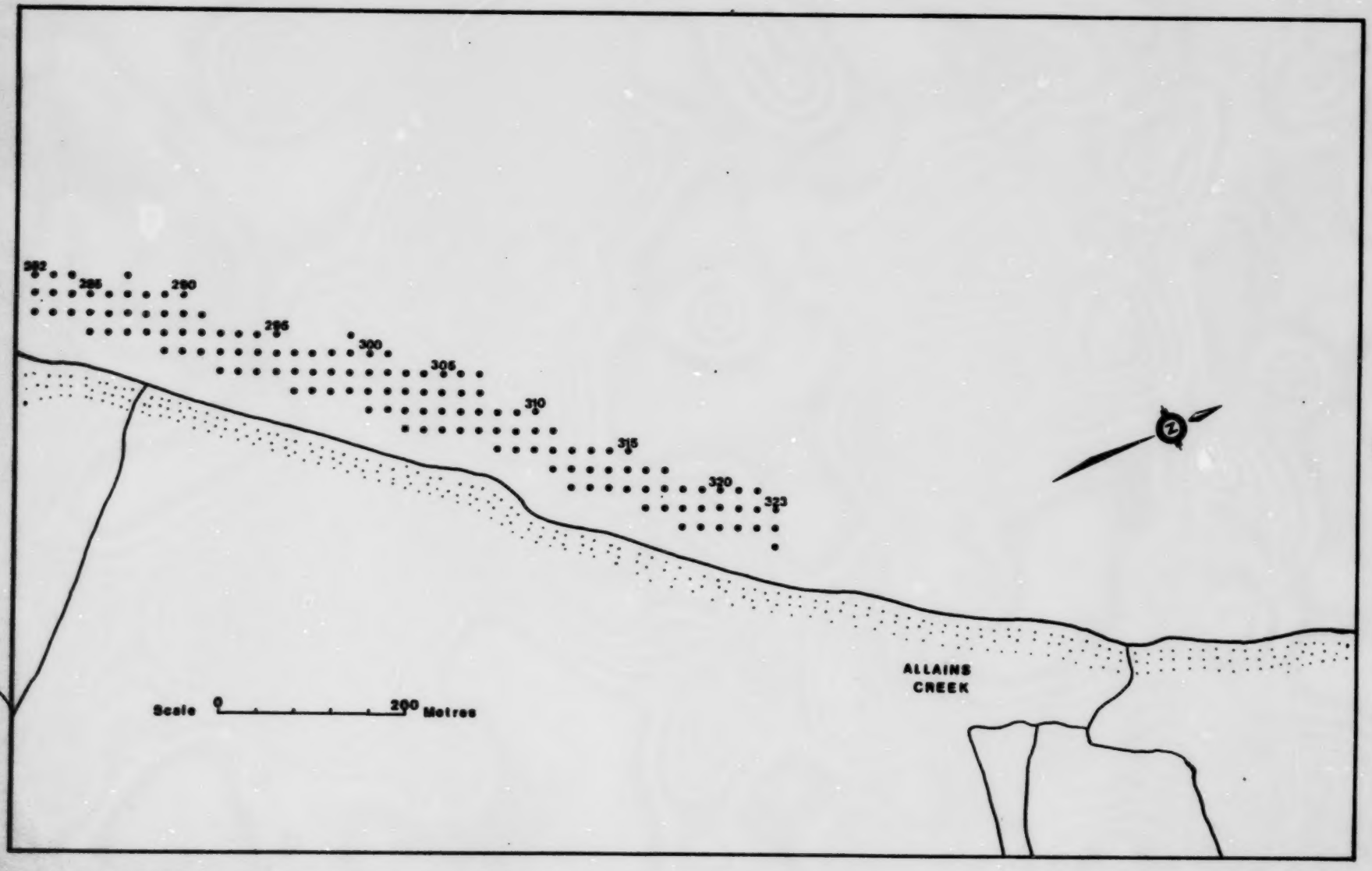


Fig. 8. Allains Creek Area "A" sample distribution.

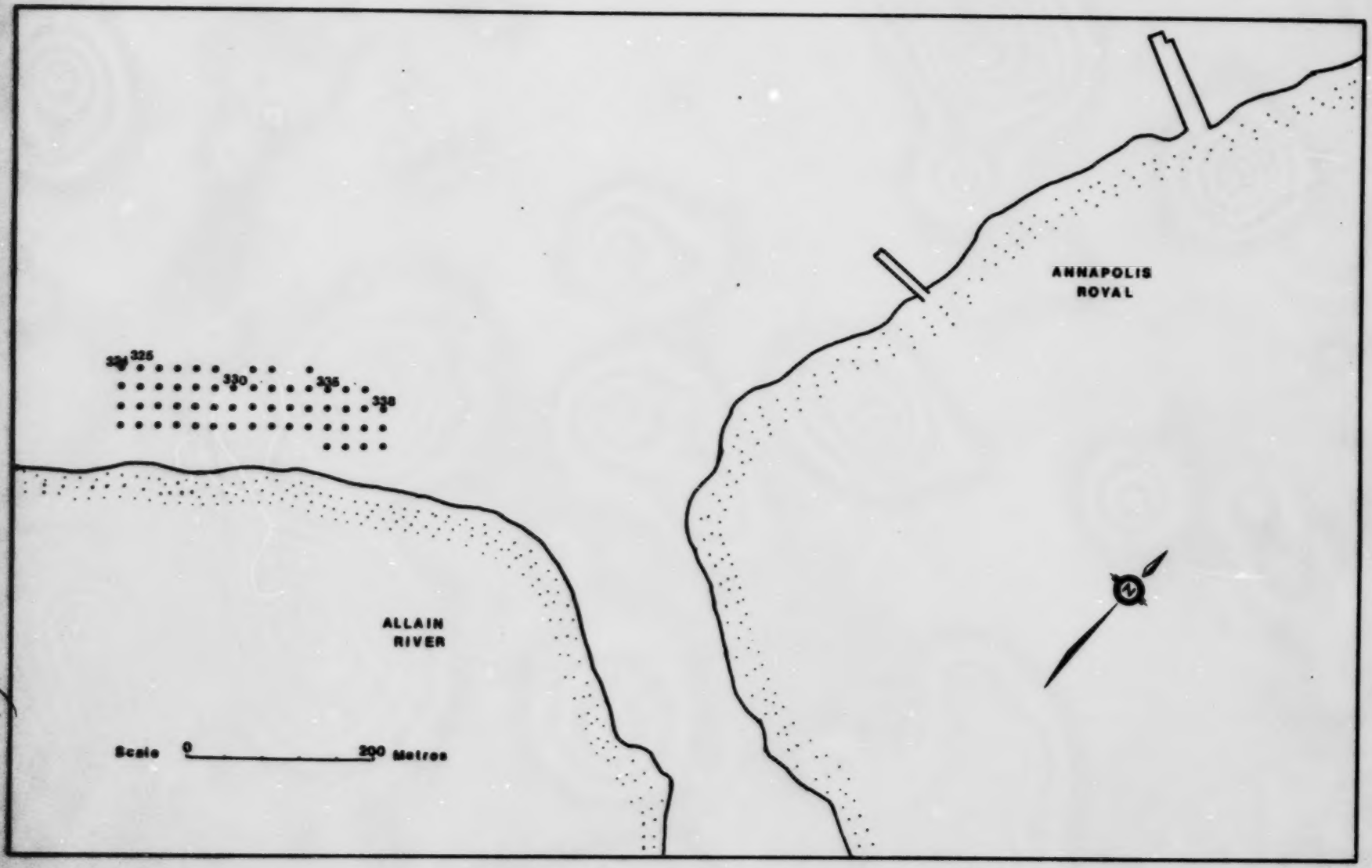


Fig. 9. Annapolis Royal Area "A" sample distribution.

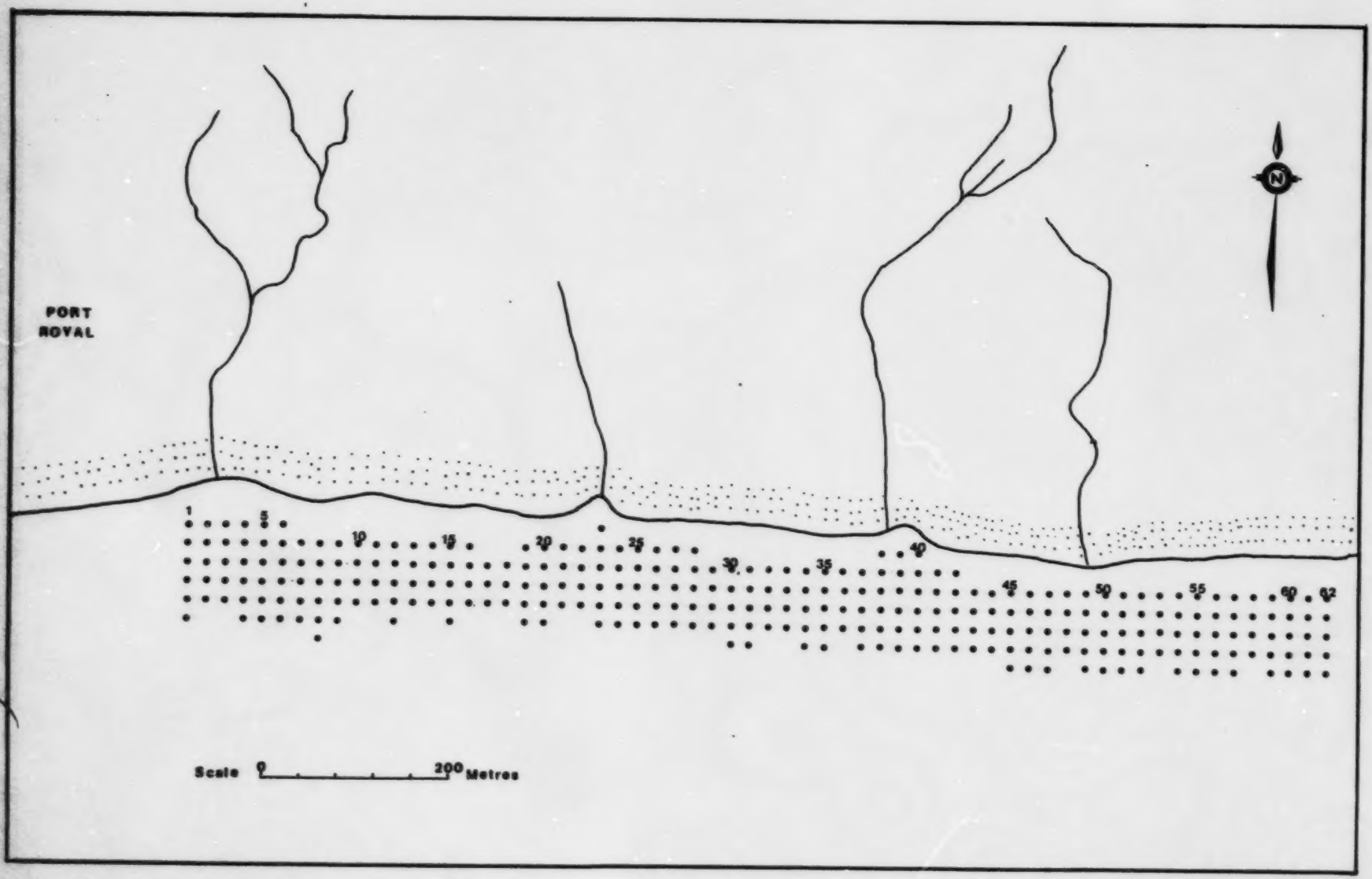


Fig. 10. Port Royal Area "B1" sample distribution.

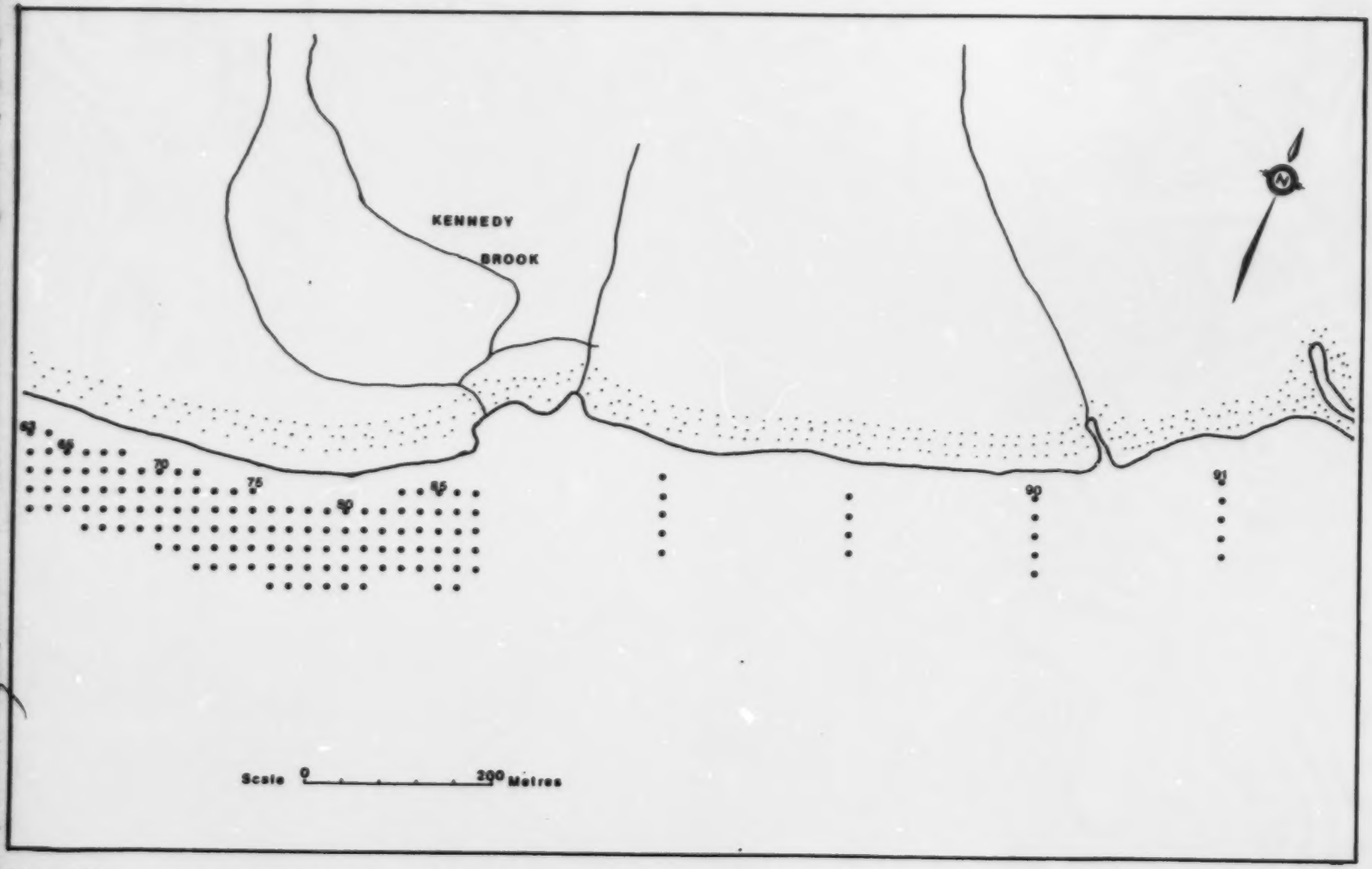


Fig. 11. Kennedy Brook Area "B1"/"B2" sample distribution.

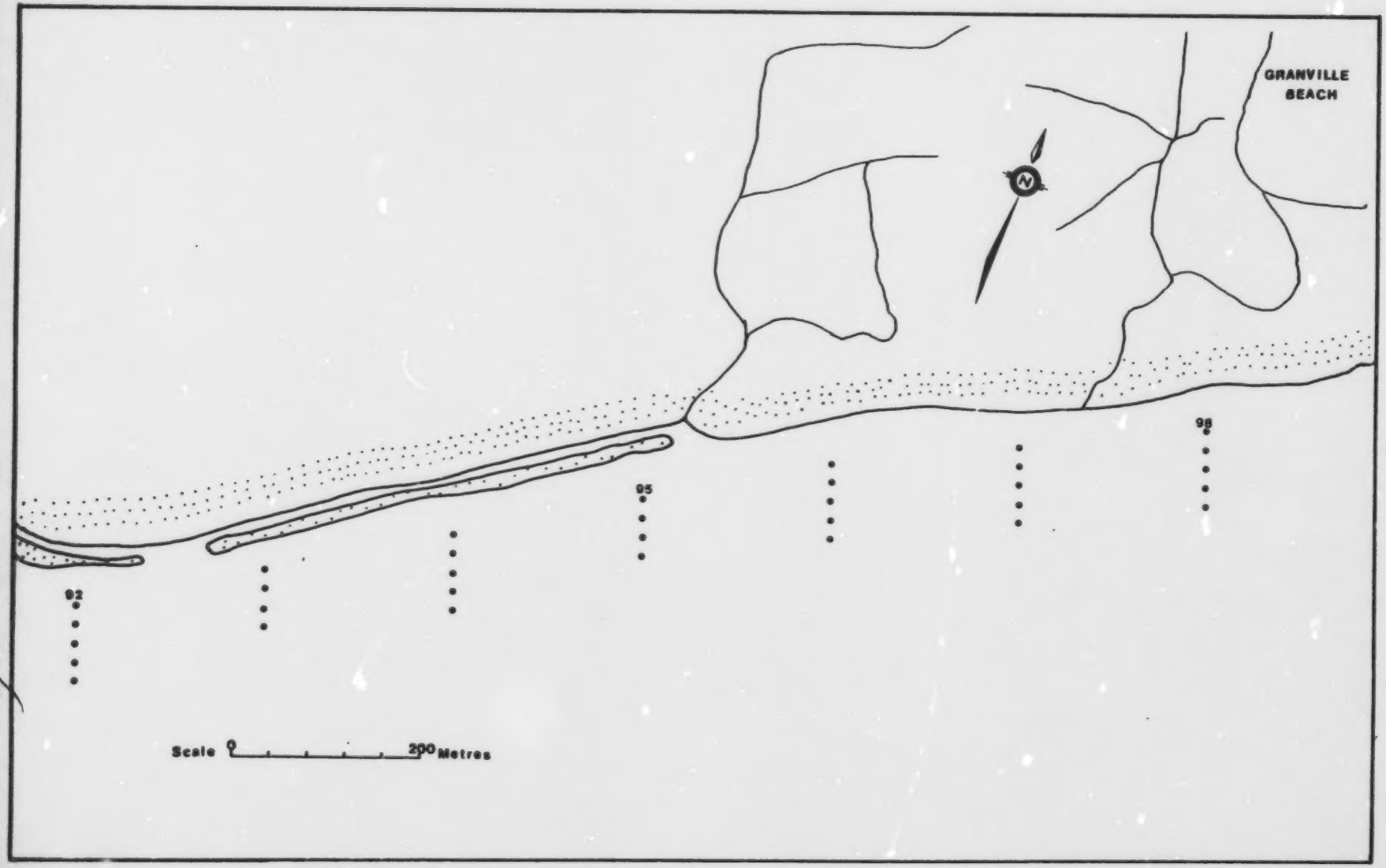


Fig. 12. Granville Beach Area "B2" sample distribution.

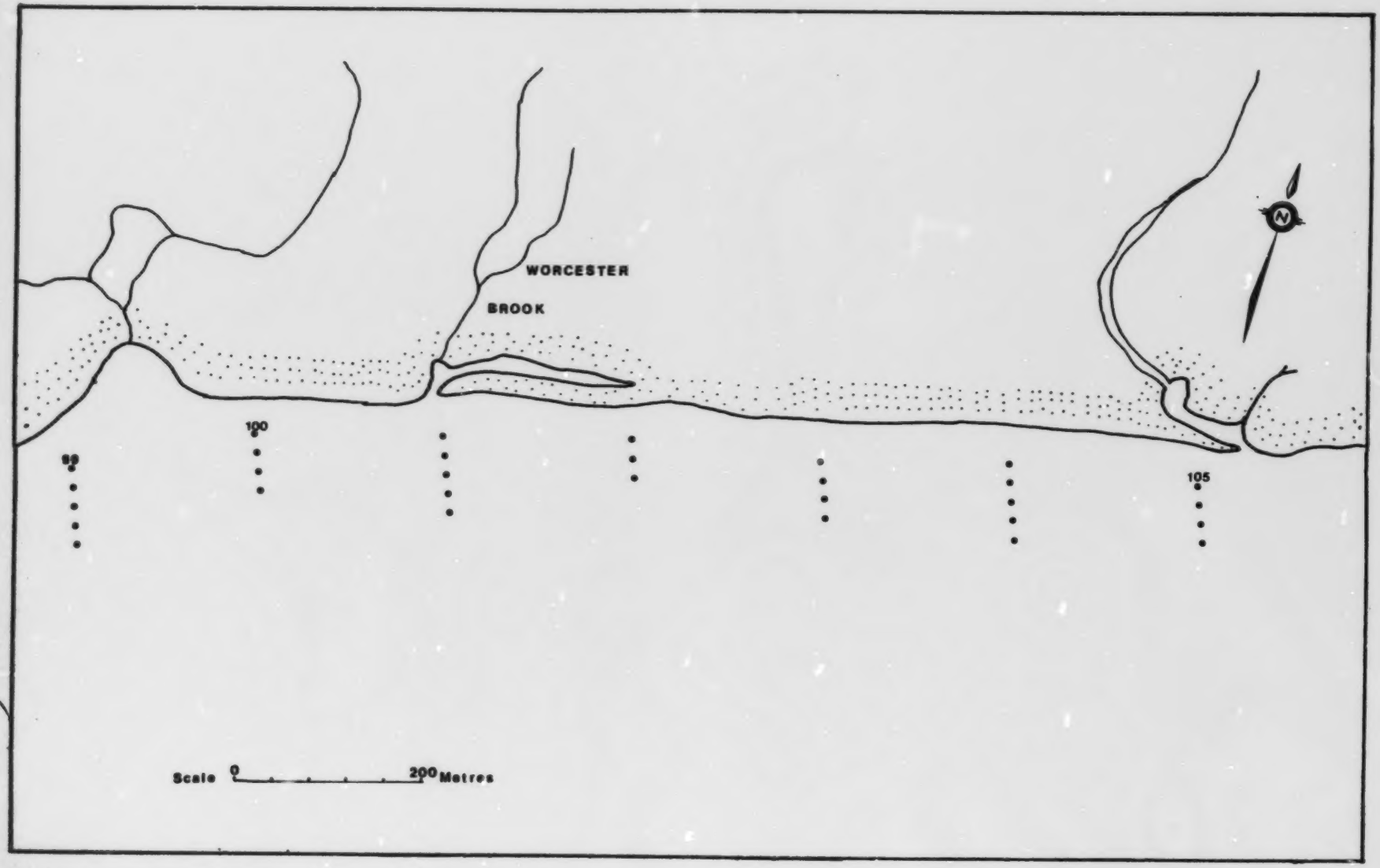


Fig. 13. Worcester Brook Area "B2" sample distribution.

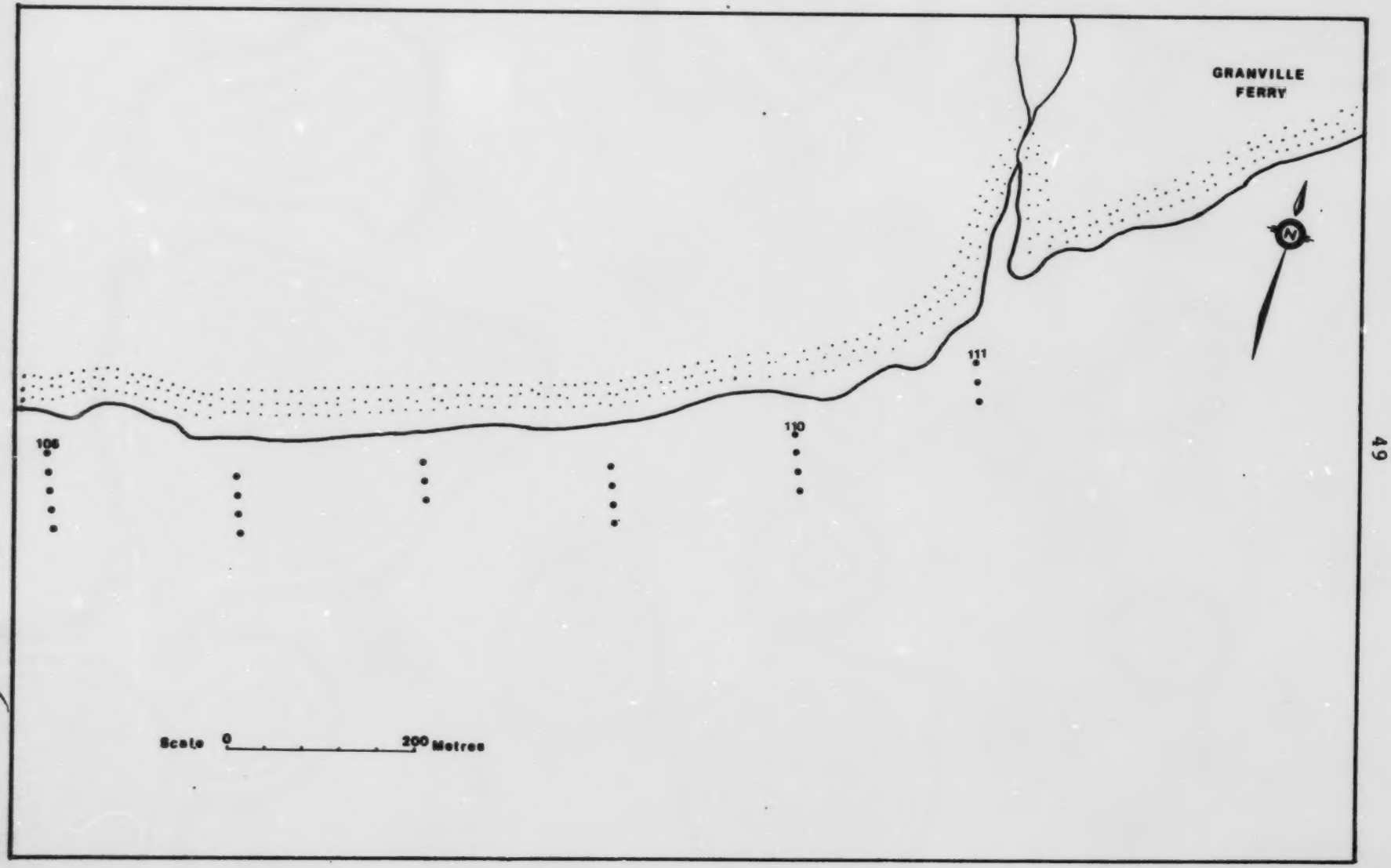


Fig. 14. Granville Ferry Area "B2" sample distribution.

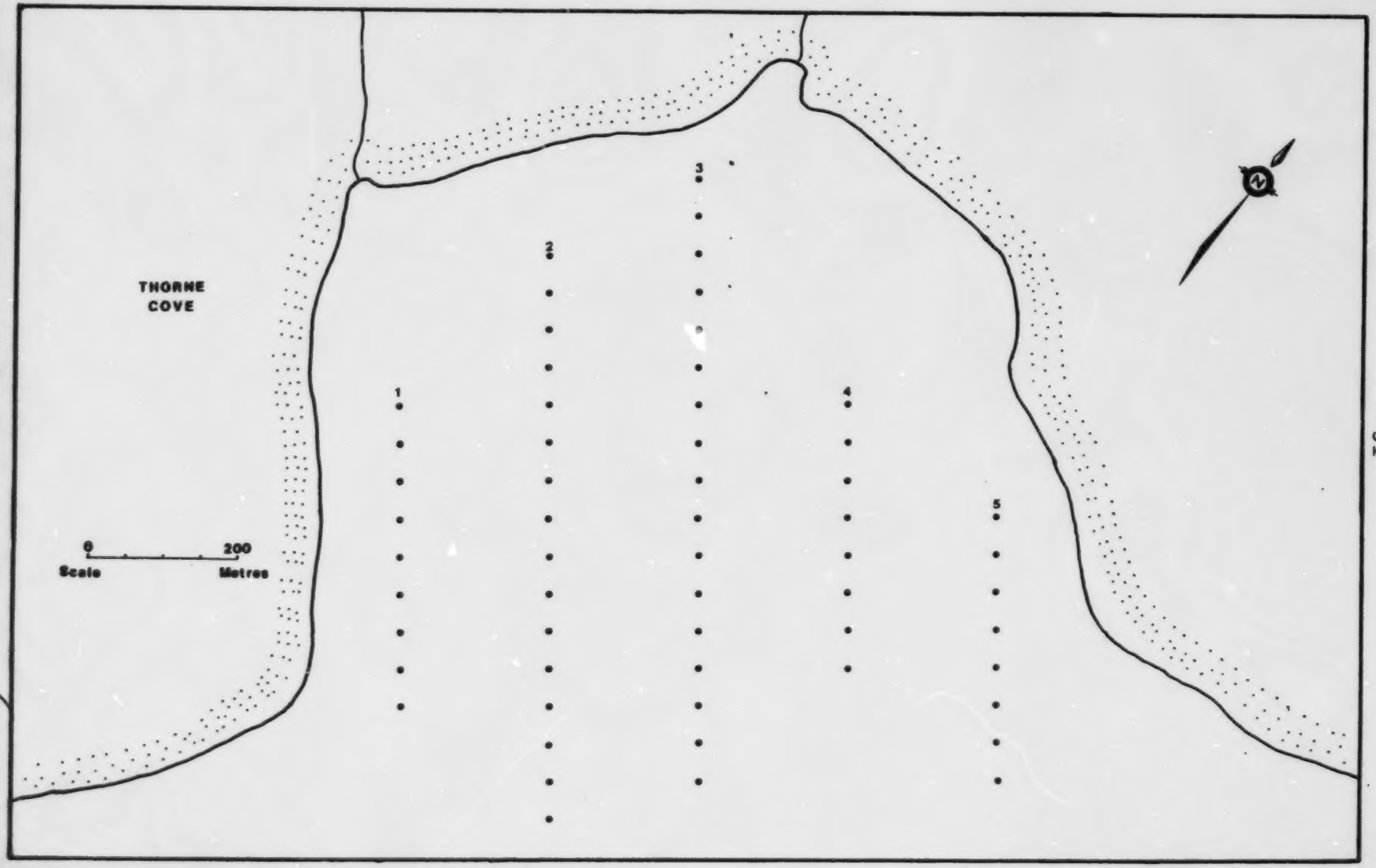


Fig. 15. Thorne Cove sample distribution.

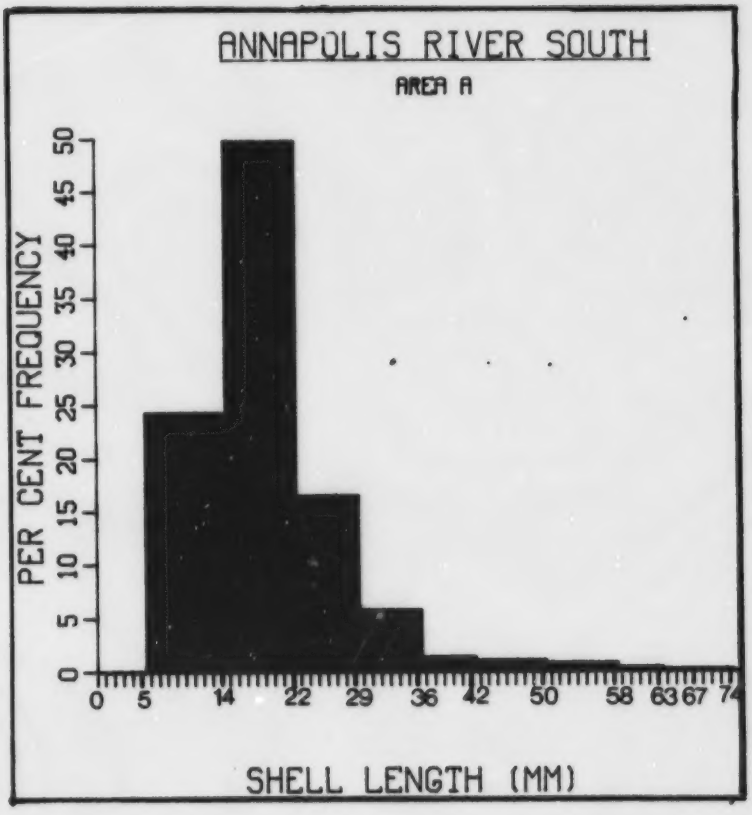


Fig. 16. Size frequency distribution - Area "A".

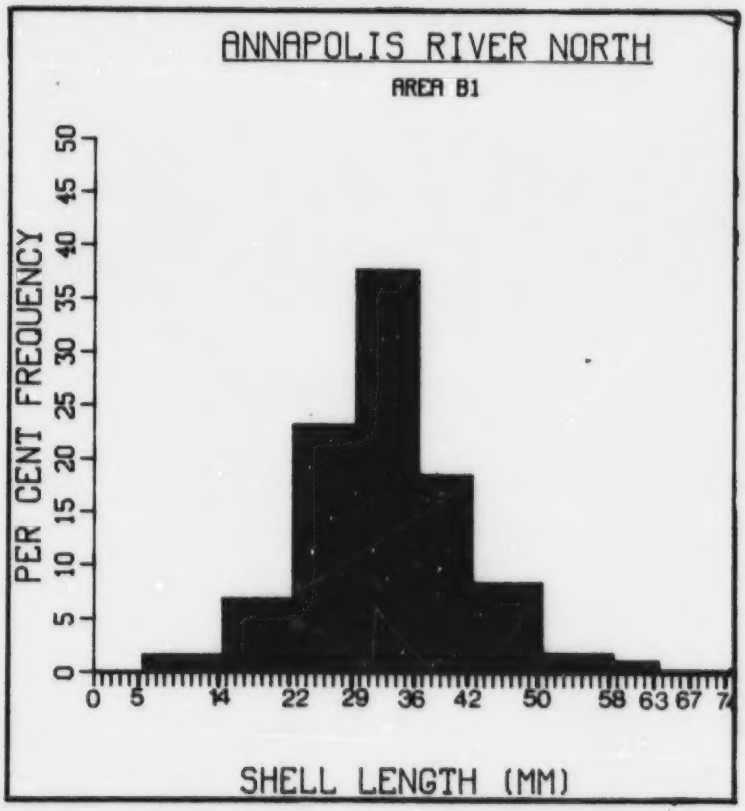


Fig. 17. Size frequency distribution - Area "B1".

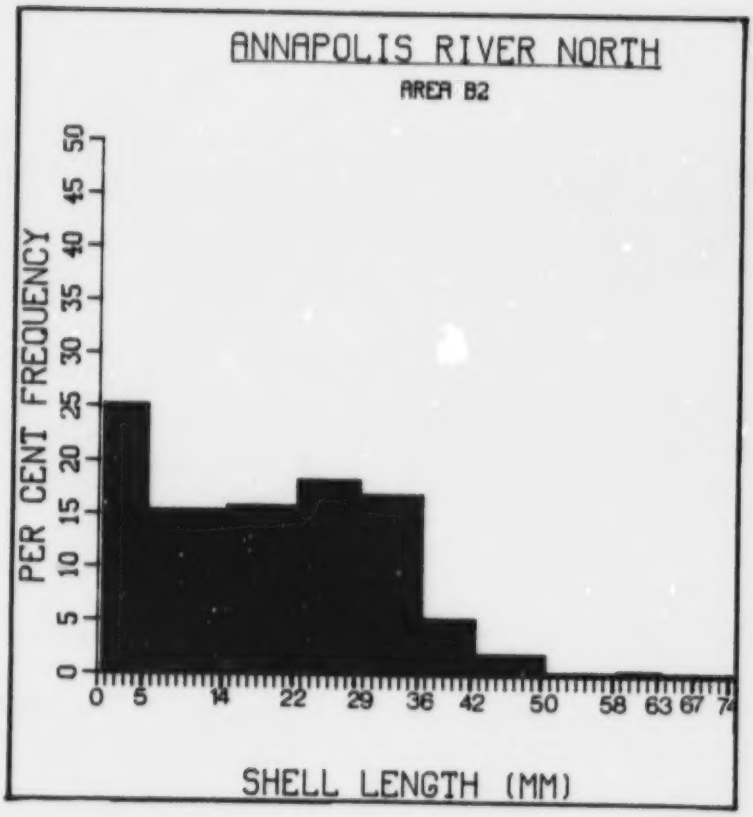


Fig. 18. Size frequency distribution - Area "B2".

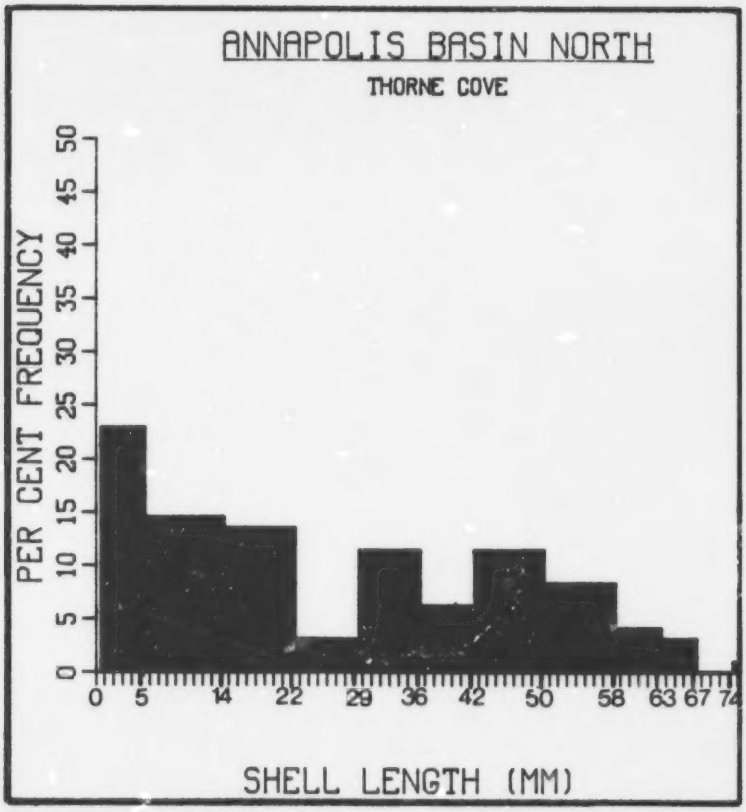

ANNAPOLIS BASIN NORTH
THORNE COVE
PER CENT FREQUENCY
0 5 10 15 20 25 30 35 40 45 50
0 5 14 22 29 36 42 50 58 63 67 74
SHELL LENGTH (MM)

Fig. 19. Size frequency distribution - Thorne Cove.

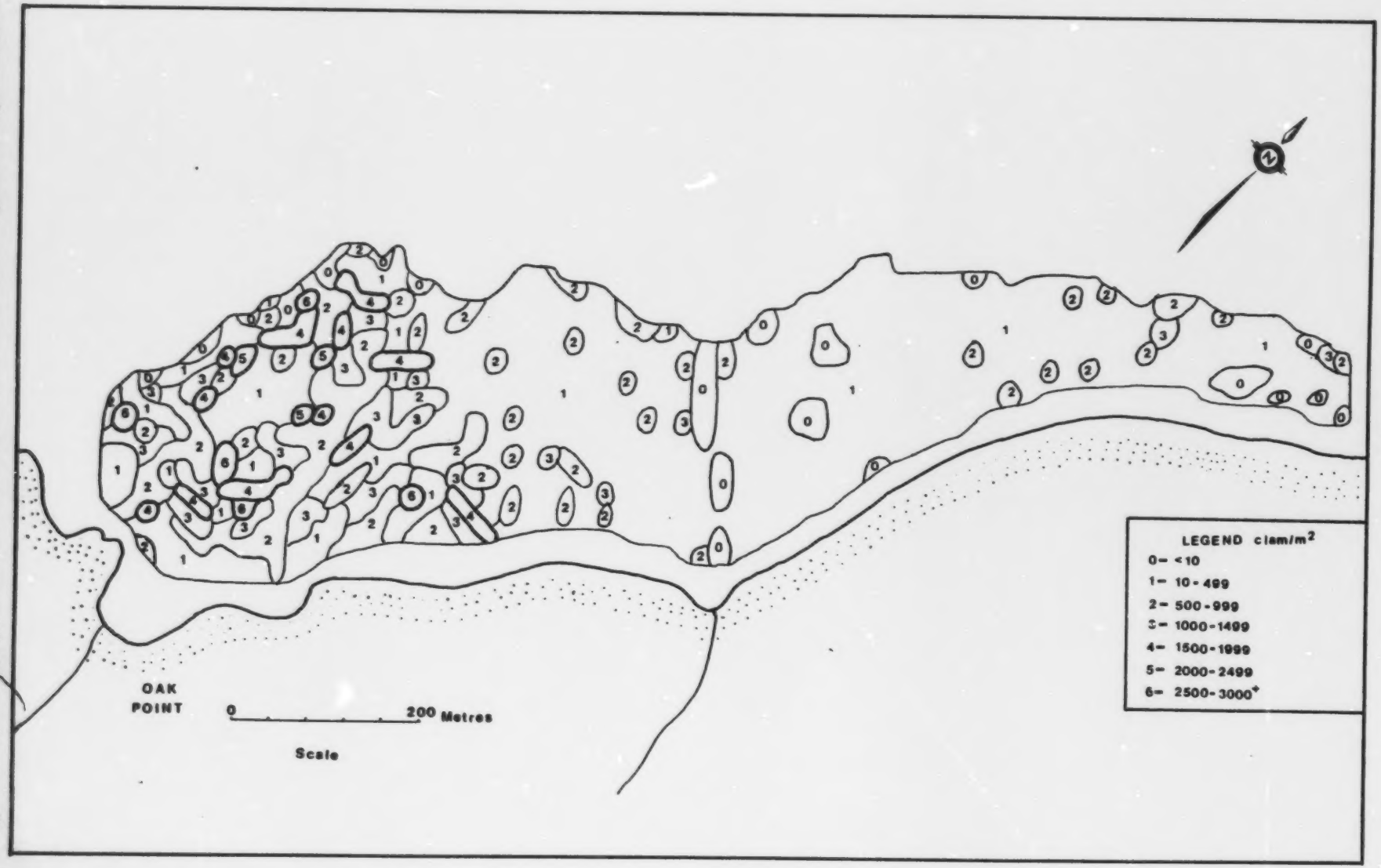


Fig. 20. Oak Point Area "A" isopleths of clam density distribution - early recruits.

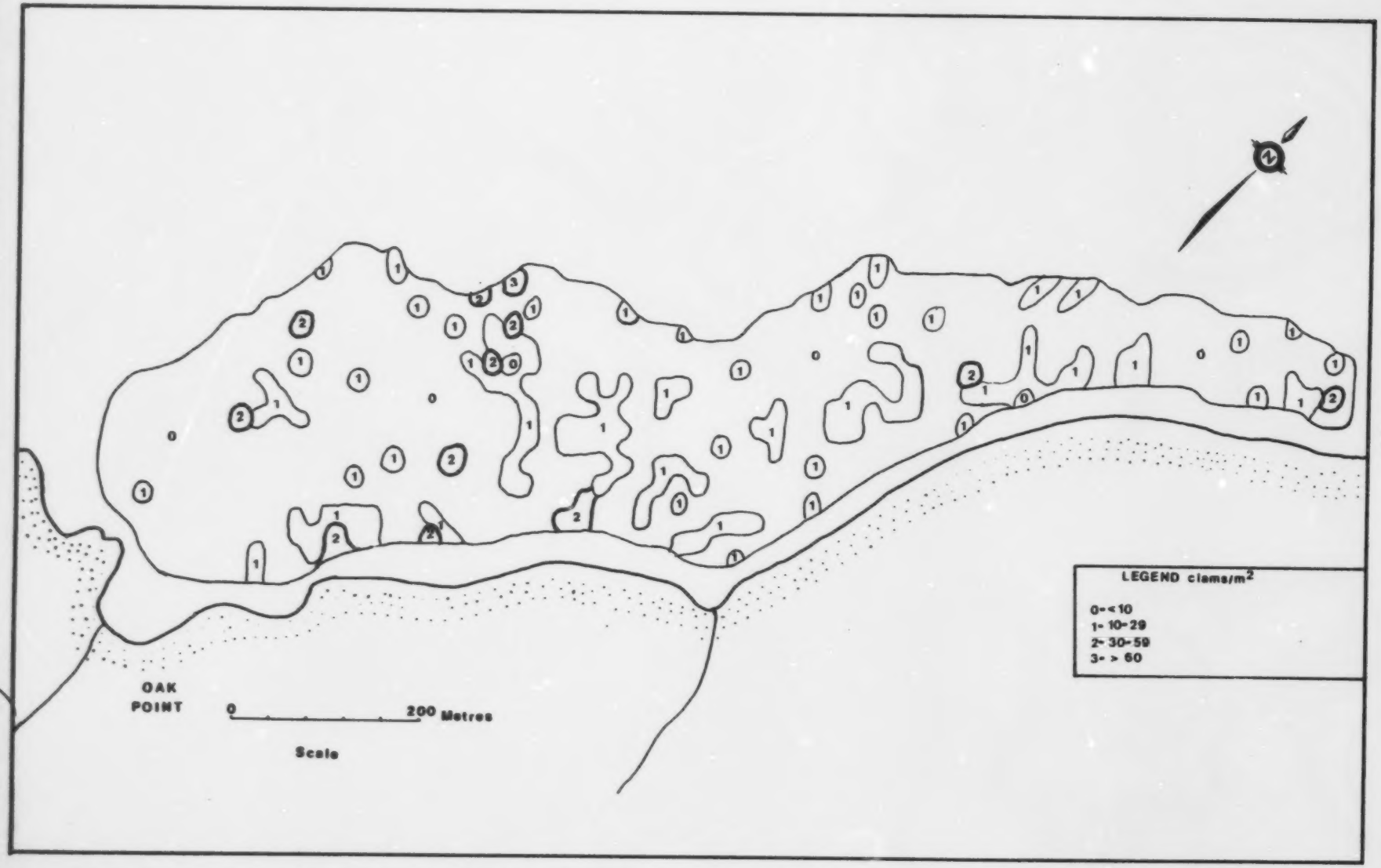


Fig. 21. Oak Point Area "A" isopleths of clam density distribution - early pre-recruits.

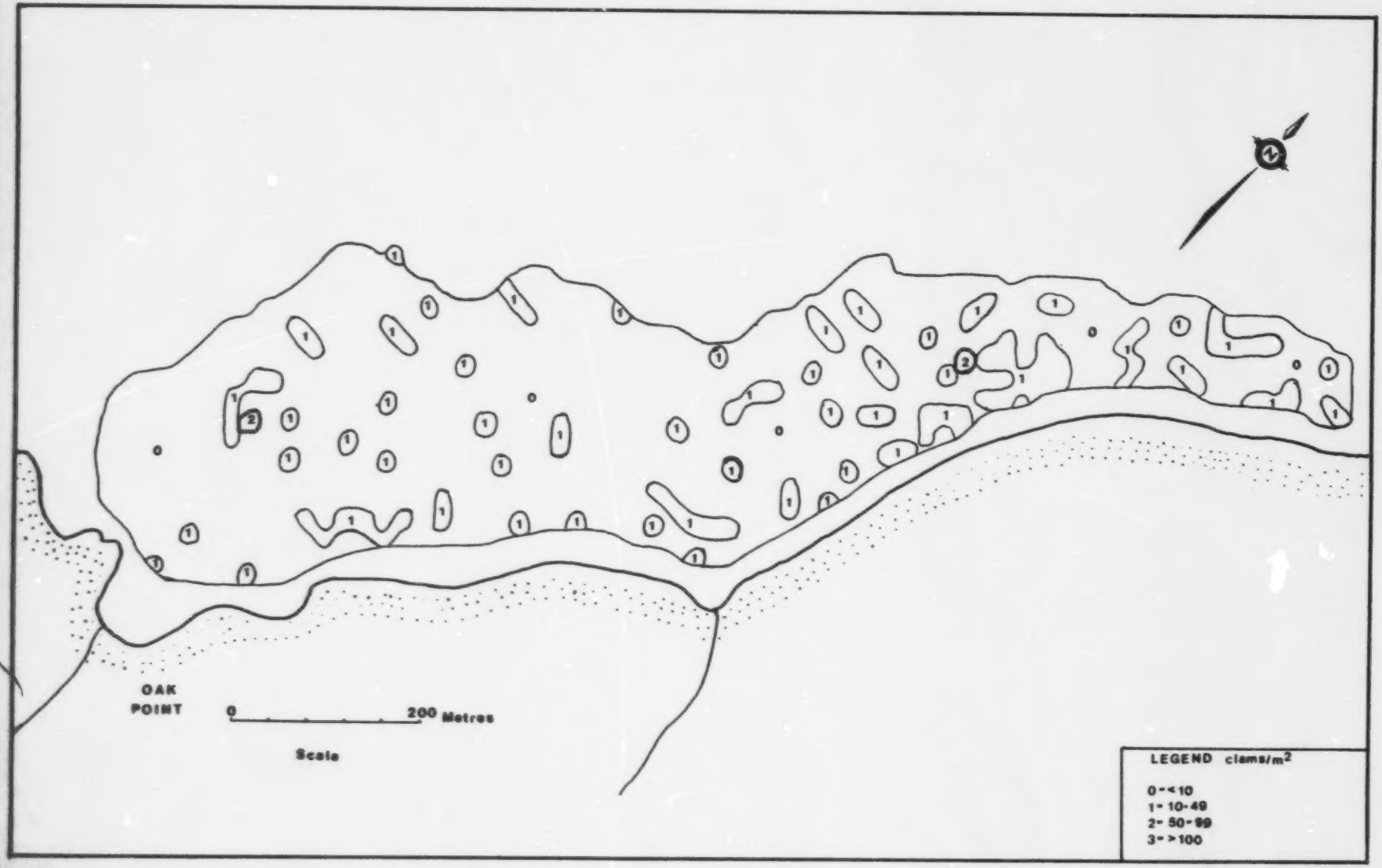


Fig. 22. Oak Point Area "A" isopleths of clam density distribution - recruits.

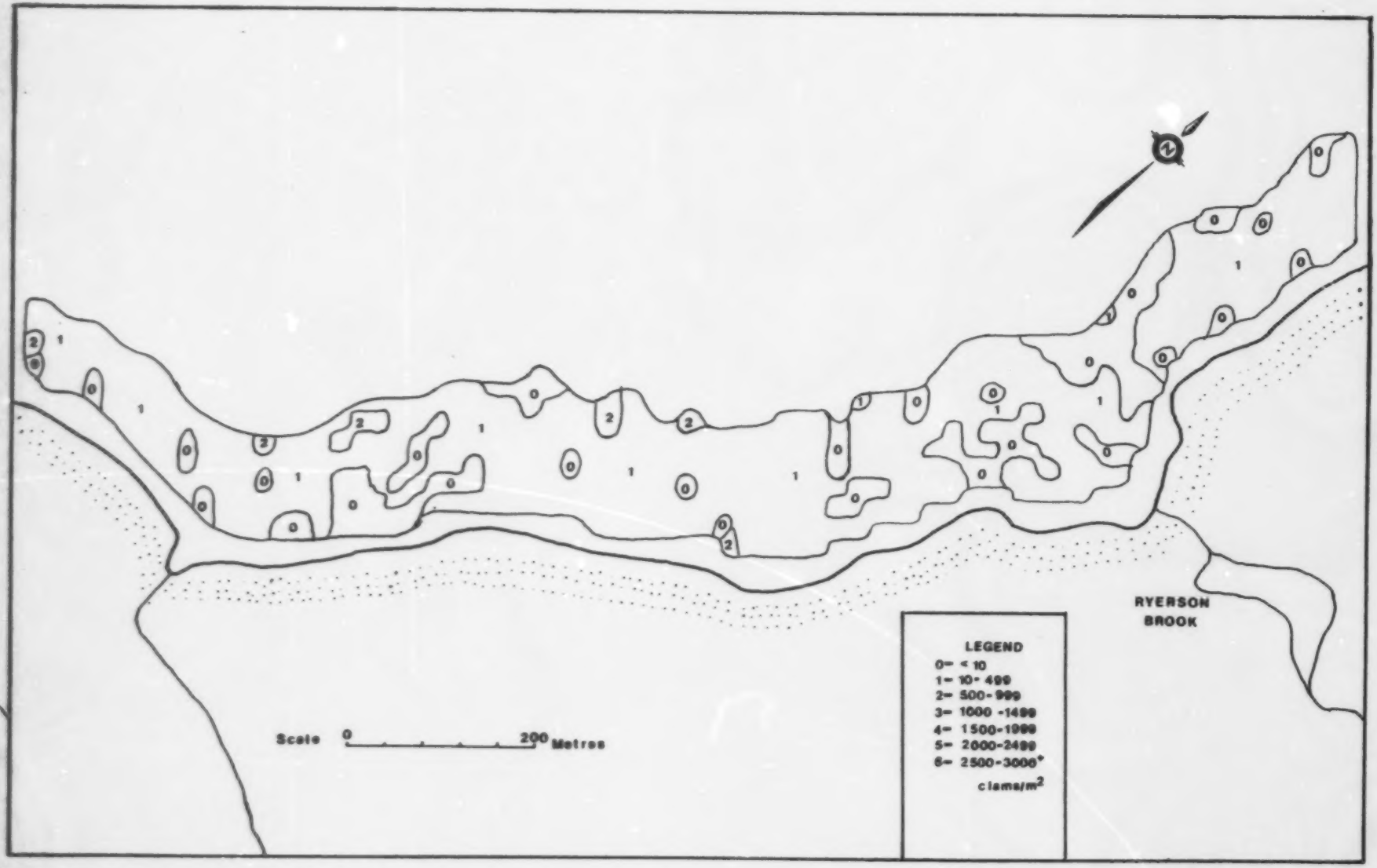


Fig. 23. Ryerson Brook Area "A" isopleths of clam density distribution - early recruits.

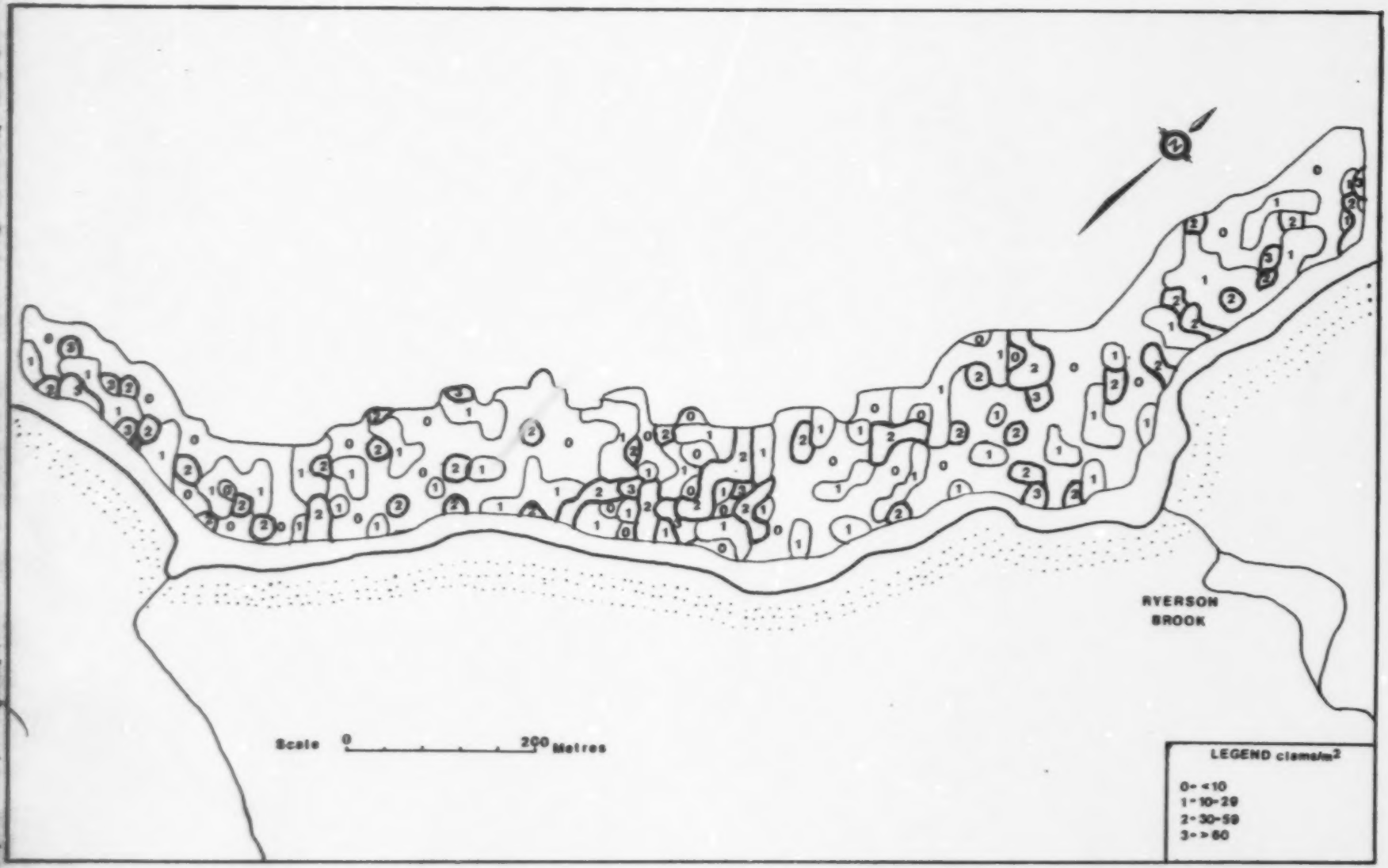


Fig. 24 Ryerson Brook Area "A" isopleths of clam density distribution - pre-recruits.

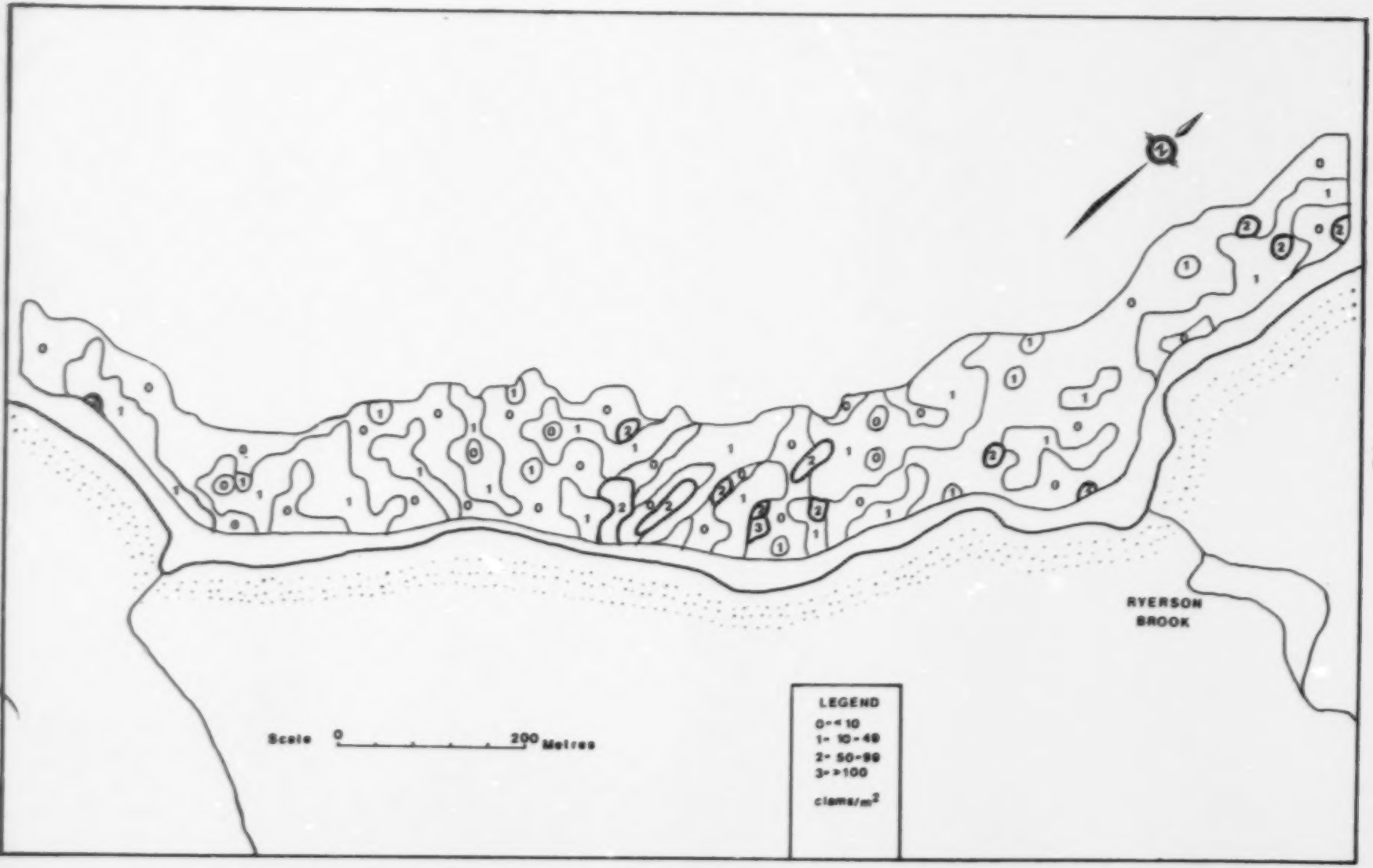


Fig. 25. Ryerson Brook Area "A" isopleths of clam density distribution - recruits.

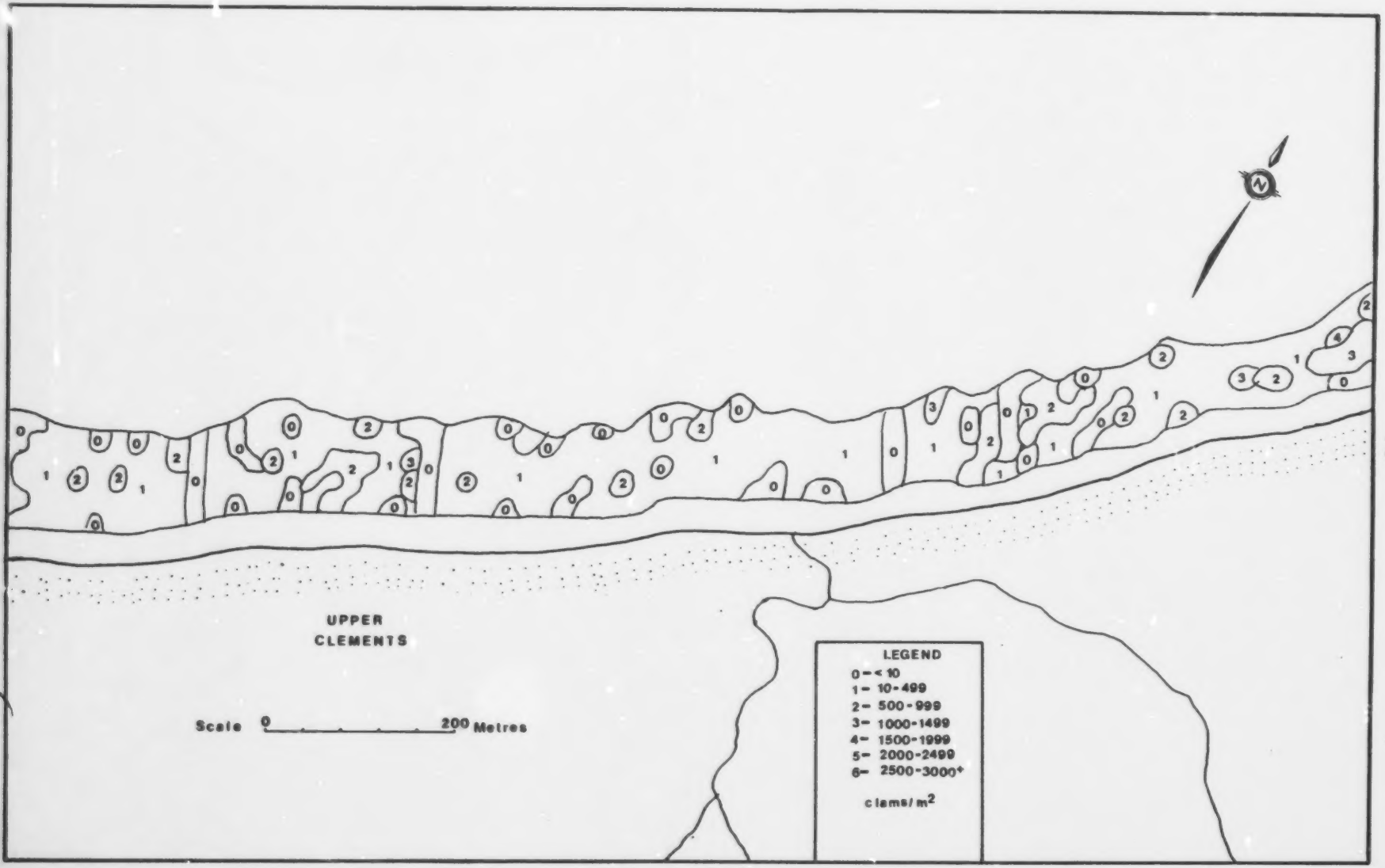


Fig. 26. Upper Clements Area "A" isopleths of clam density distribution - early recruits.

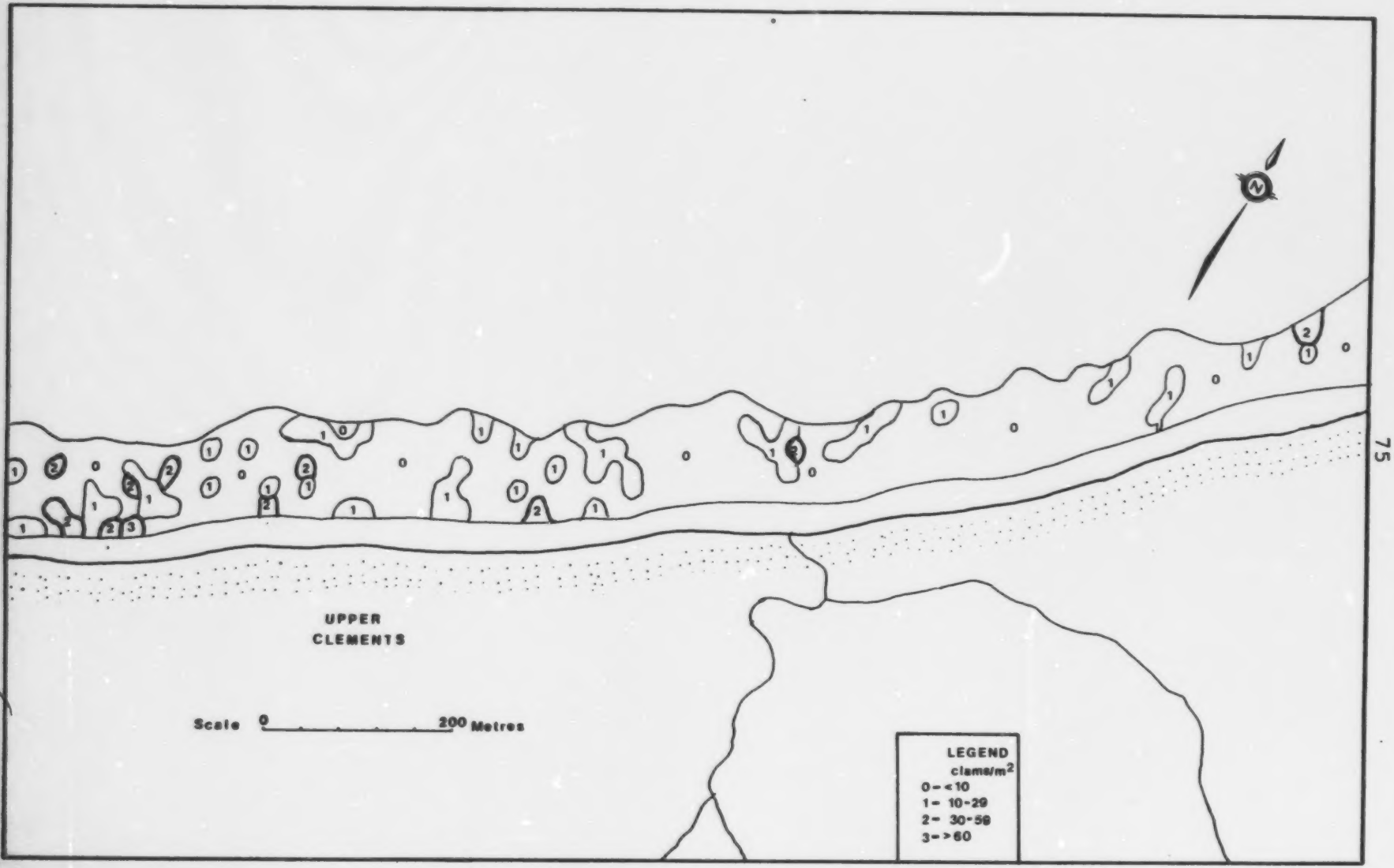


Fig. 27. Upper Clements Area "A" isopleths of clam density distribution - pre-recruits.

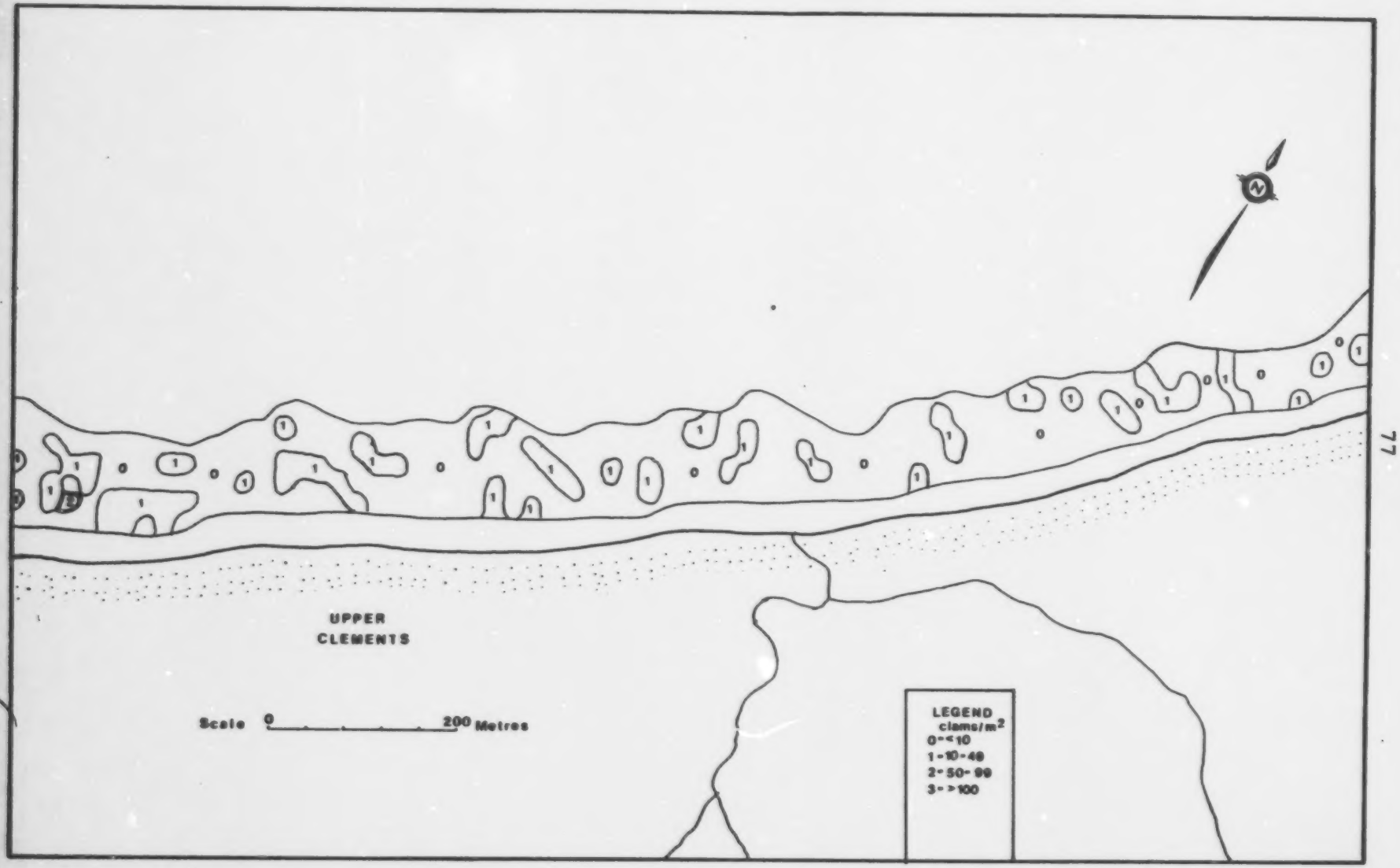


Fig. 28. Upper Clements Area "A" isopleths of clam density distribution - recruits.

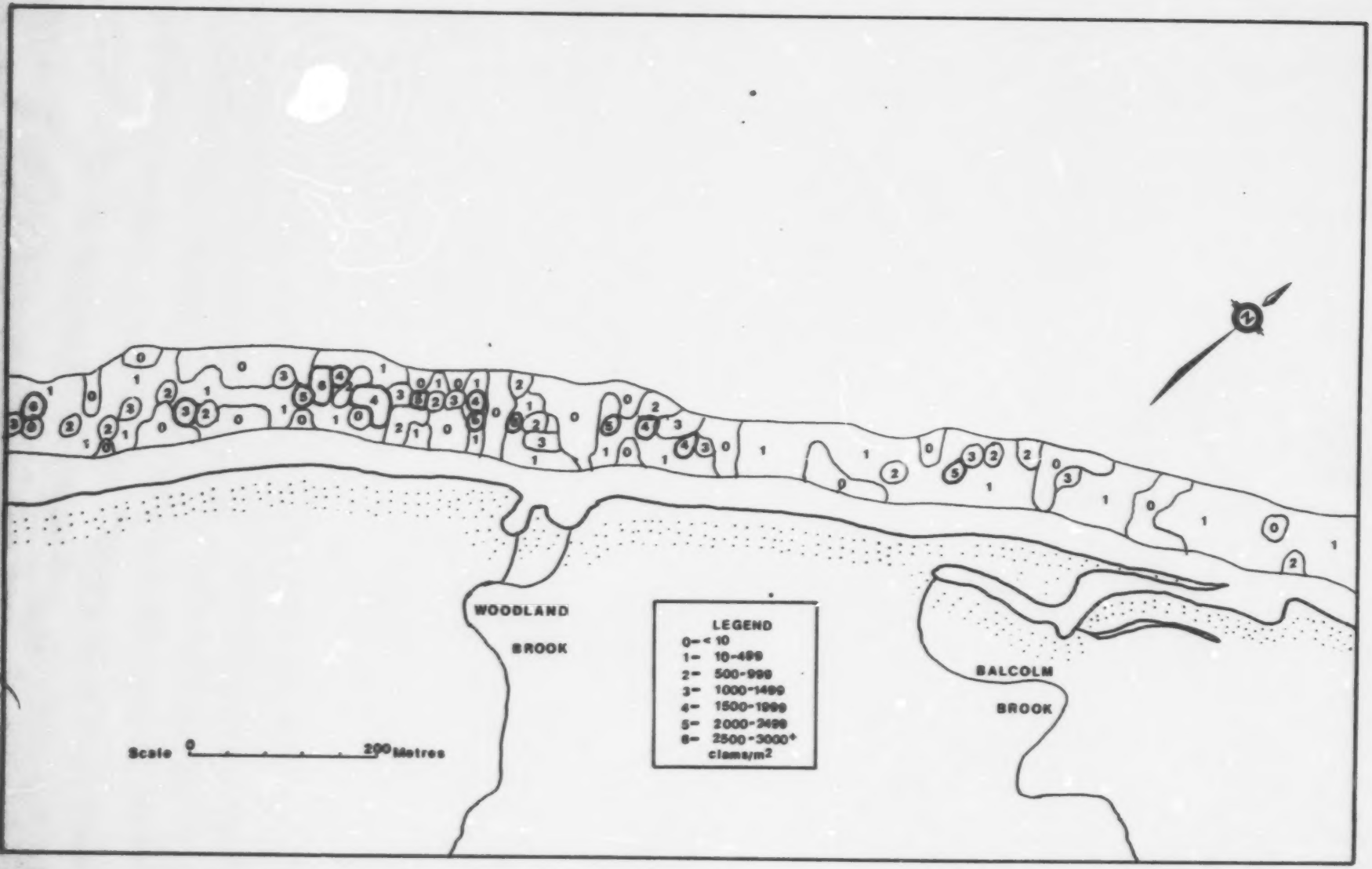
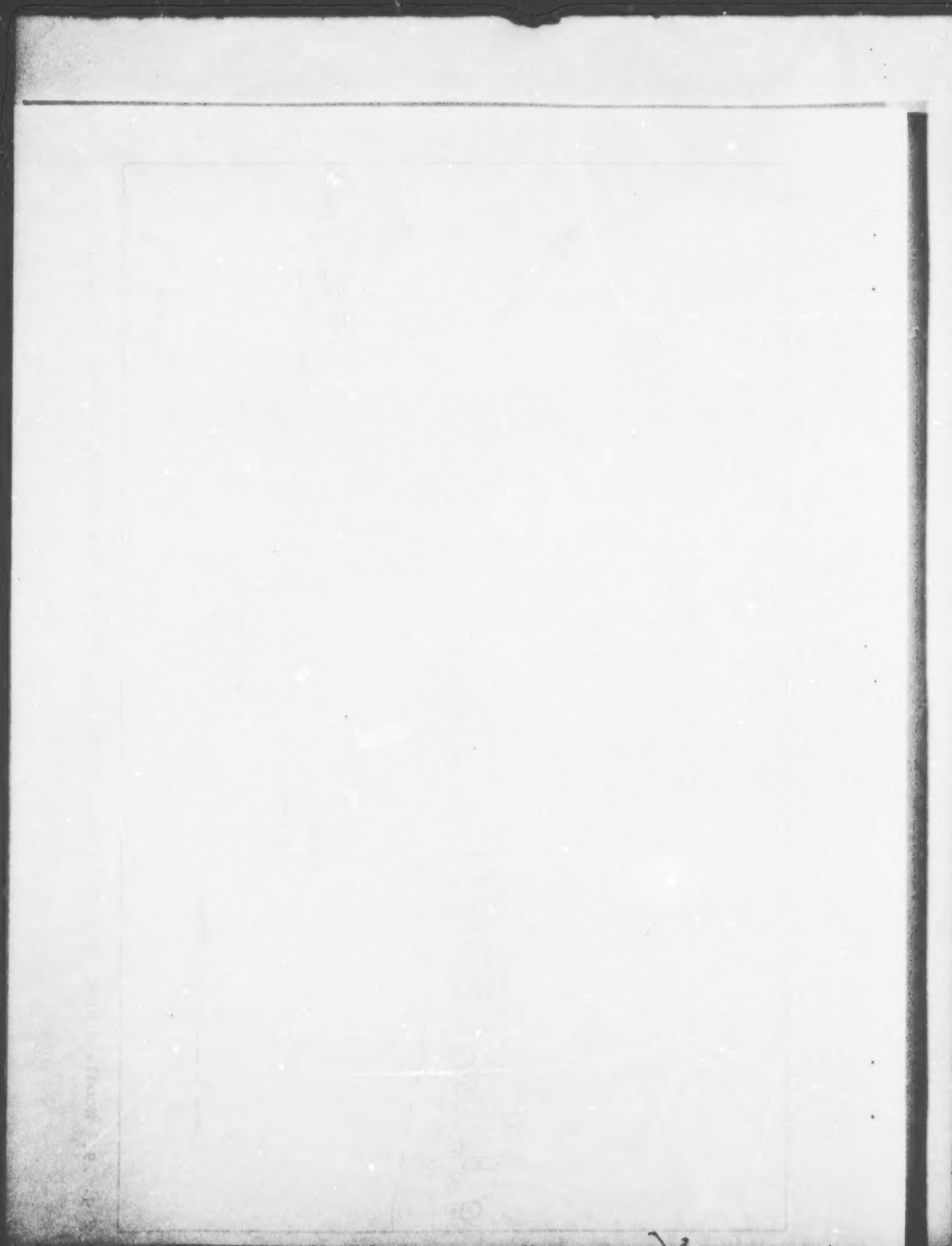


Fig. 29. Woodland Brook Area "A" isopleths of clam density distribution - early recruits.



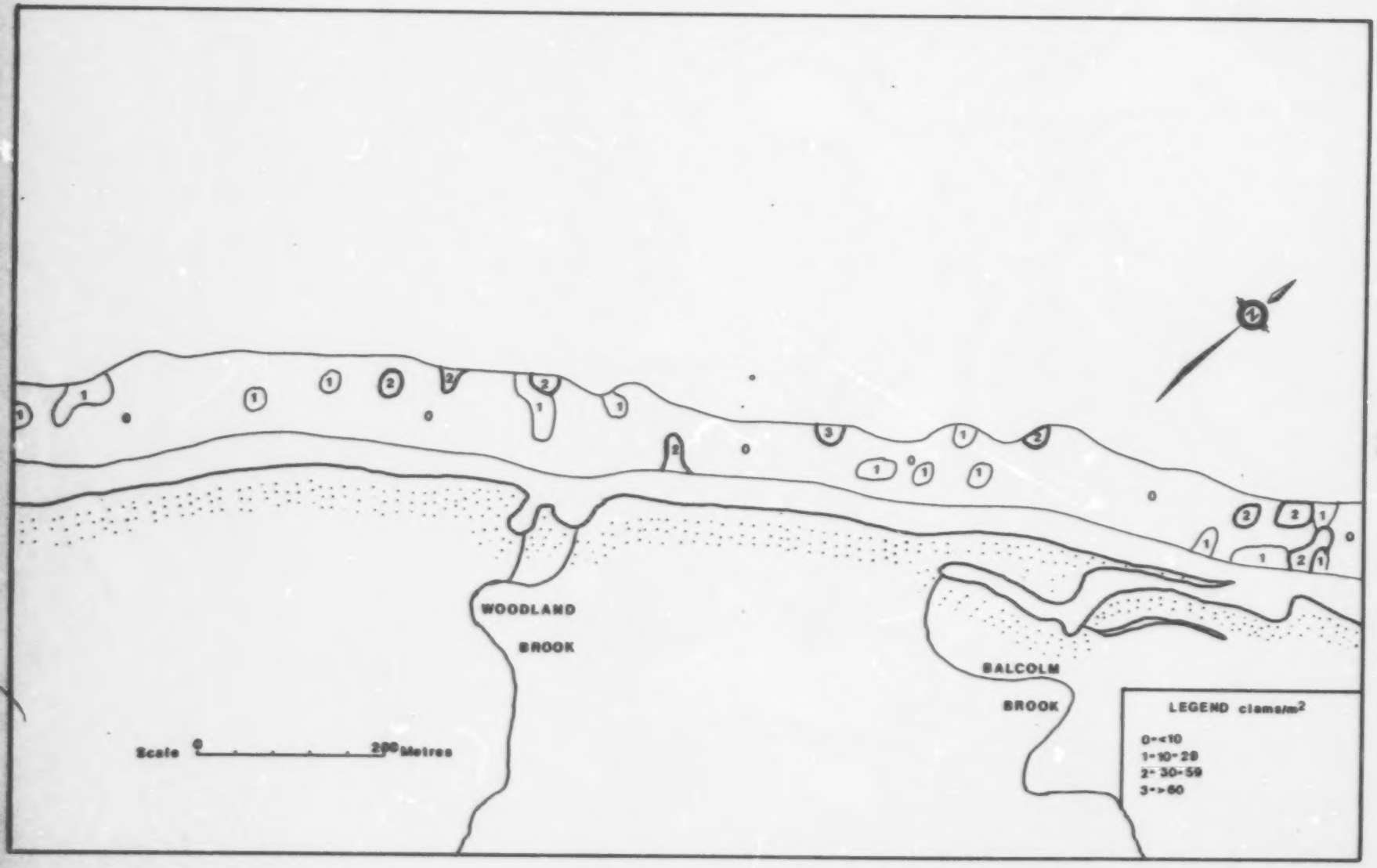


Fig. 30. Woodland Brook Area "A" isopleths of clam density distribution - pre-recruits.

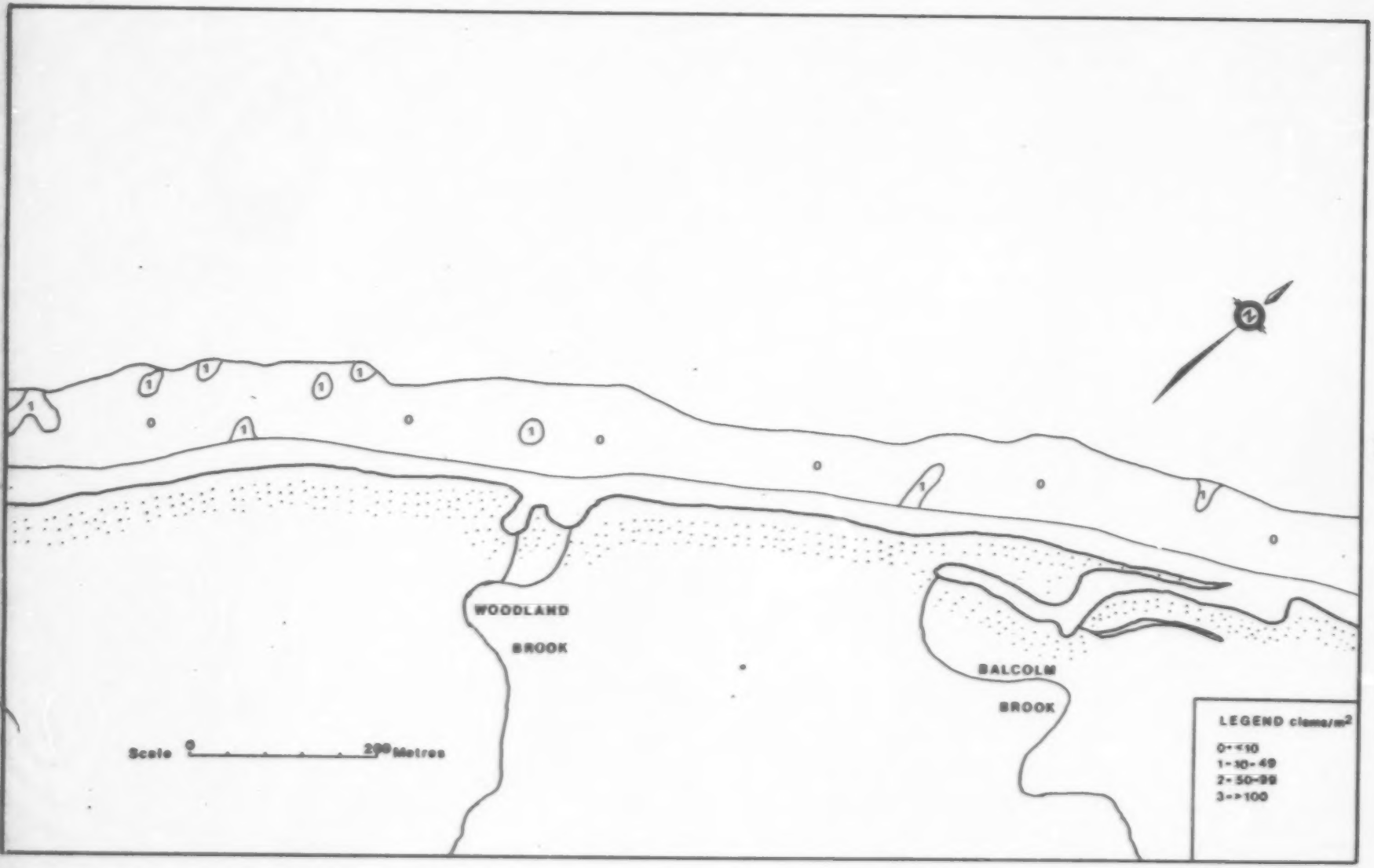


Fig. 31. Woodland Brook Area "A" isopleths of clam density distribution - recruits.

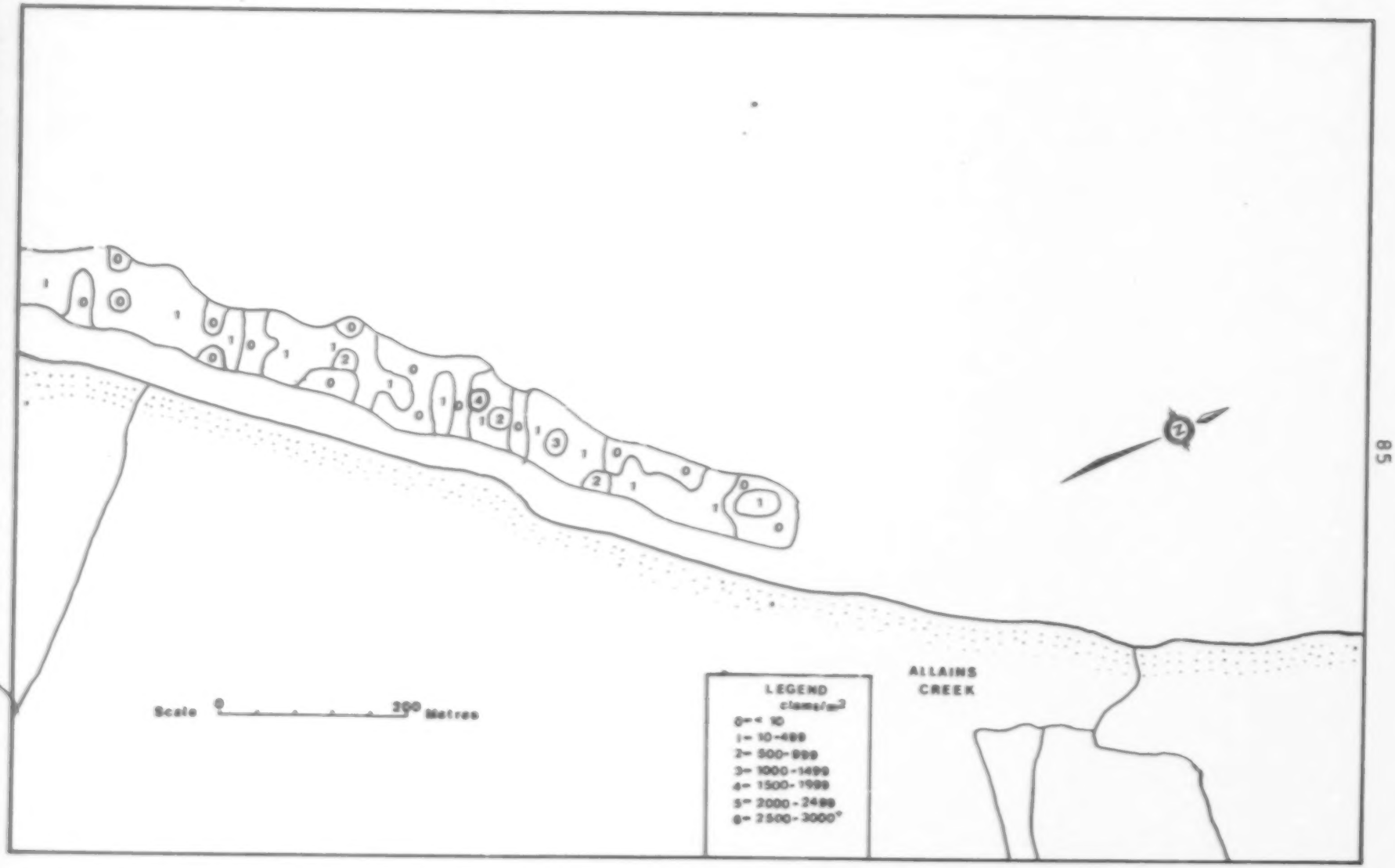


Fig. 32. Allains Creek Area "A" isopleths of clam density distribution - early recruits.

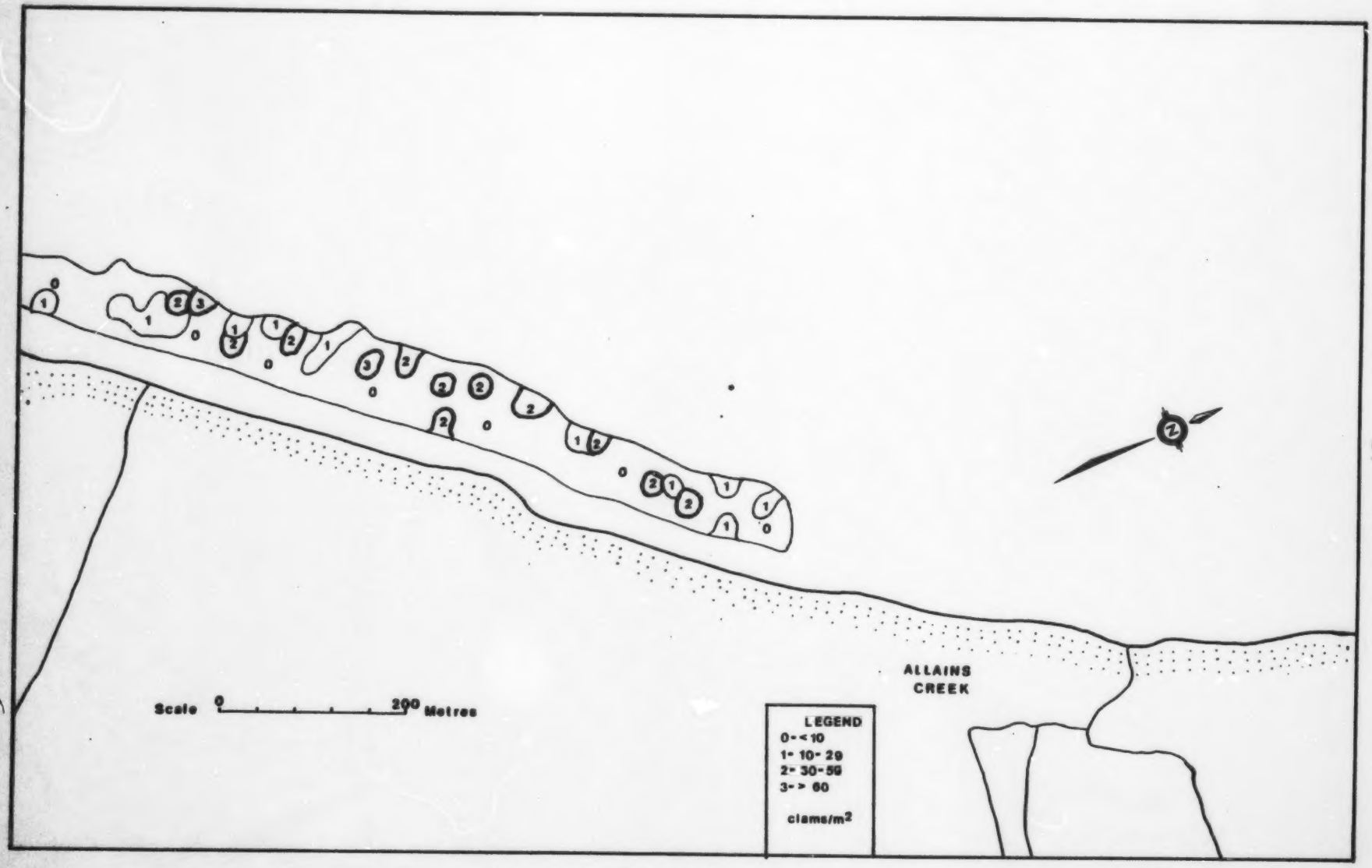


Fig. 33. Allains Creek Area "A" isopleths of clam density distribution - pre-recruits.

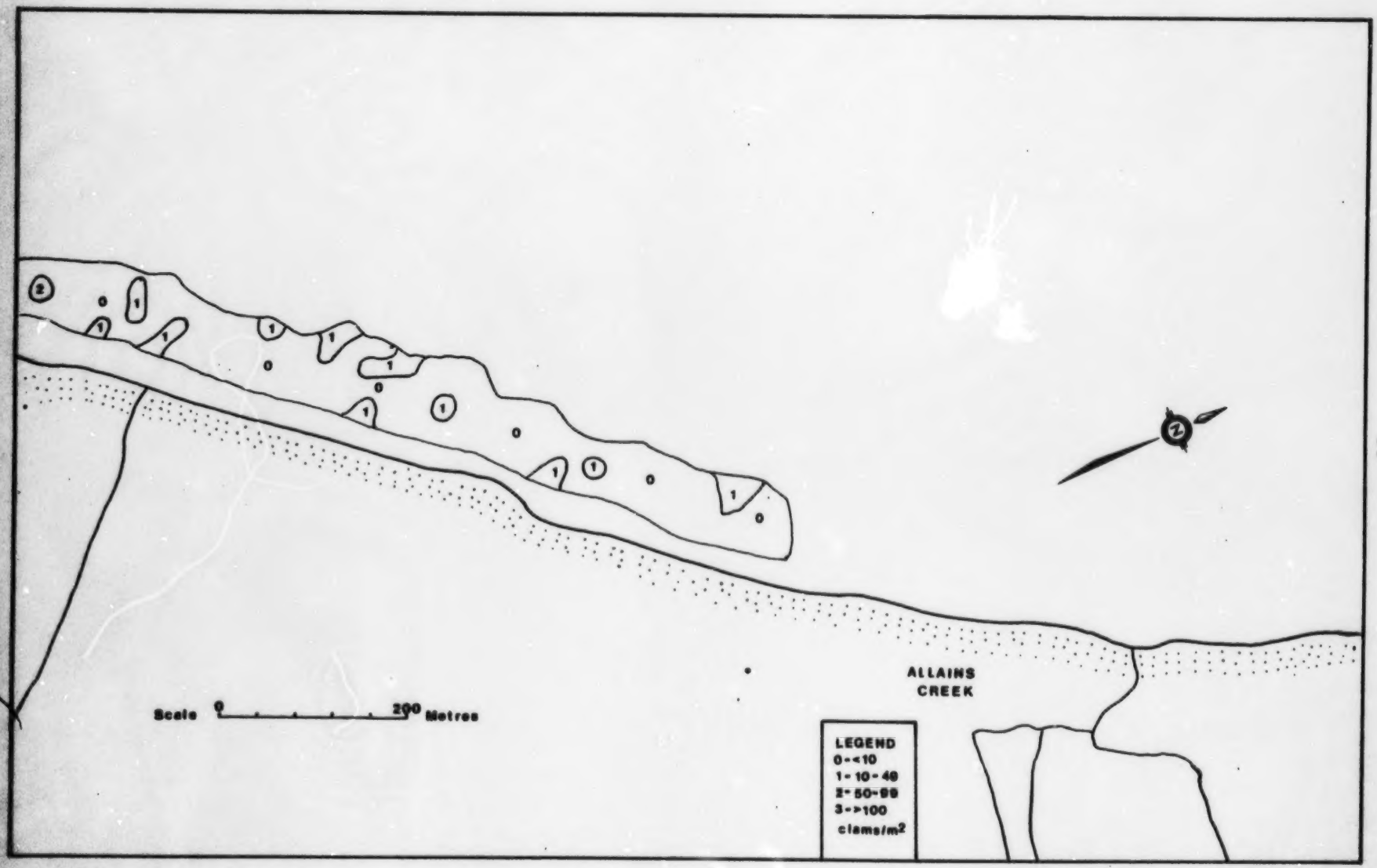


Fig. 34. Allains Creek Area "A" isopleths of clam density distribution - recruits.

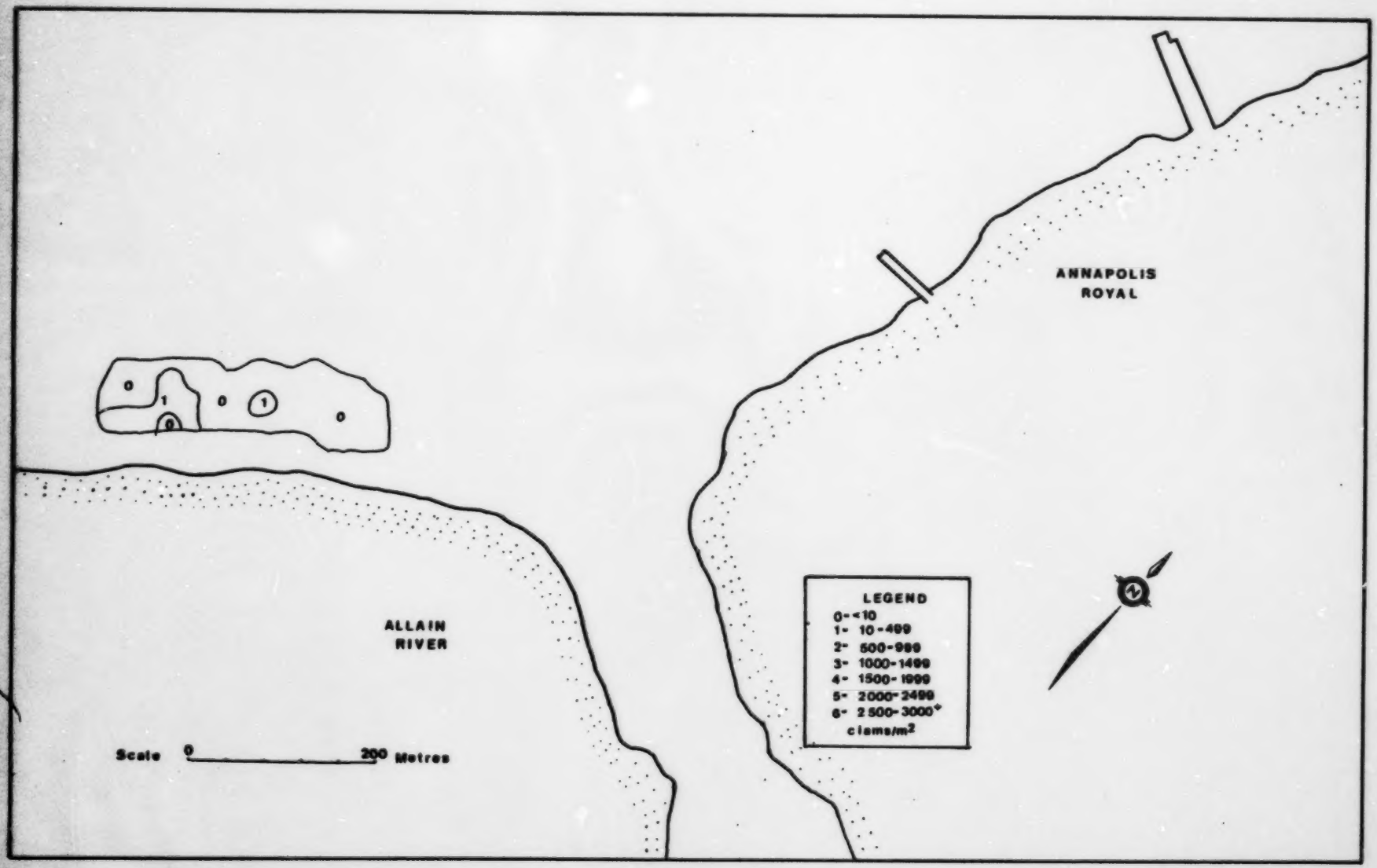


Fig. 35. Annapolis Royal Area "A" isopleths of clam density distribution - early recruits.

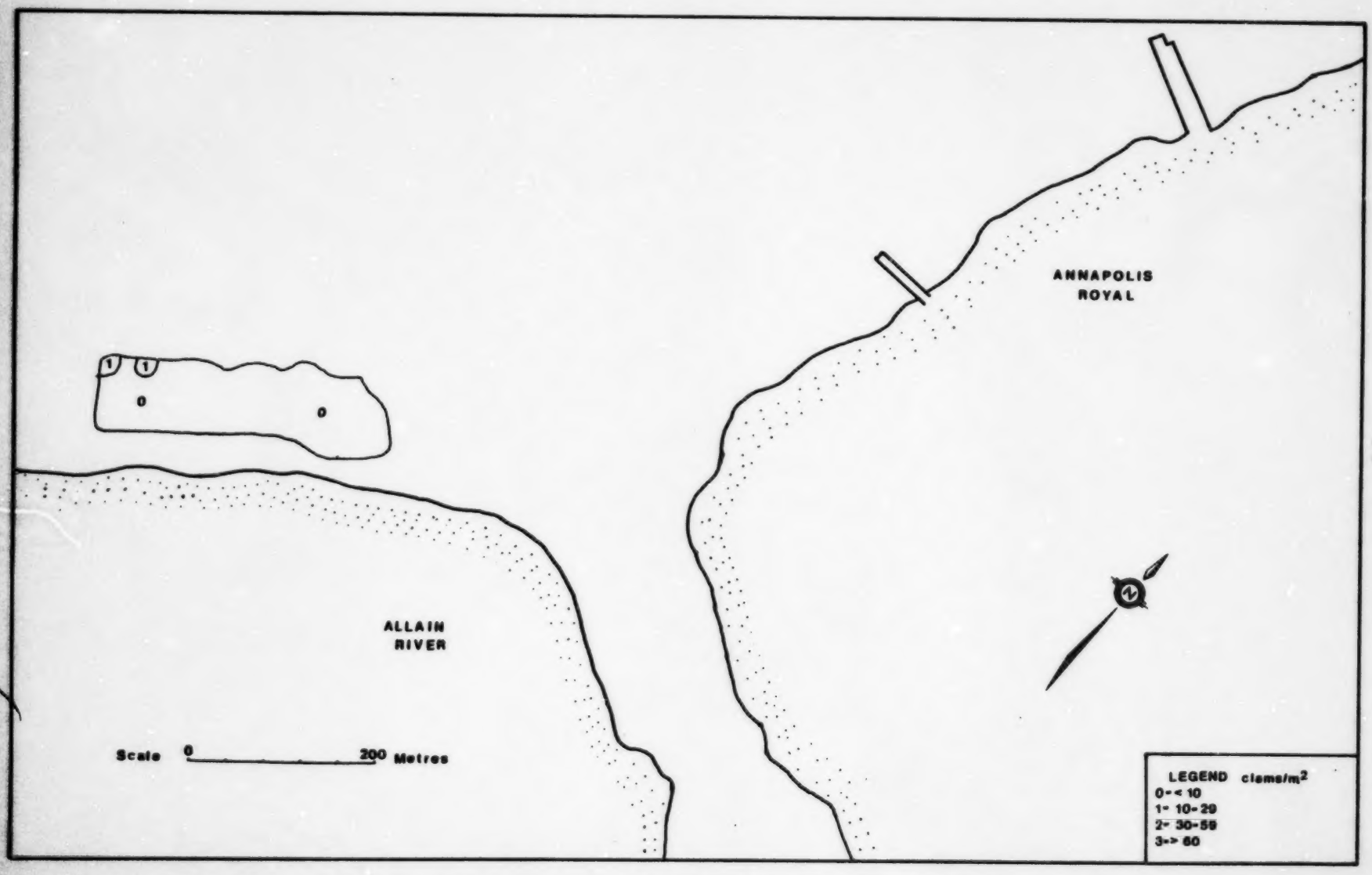


Fig. 36. Annapolis Royal Area "A" isopleths of clam density distribution - pre-recruits.

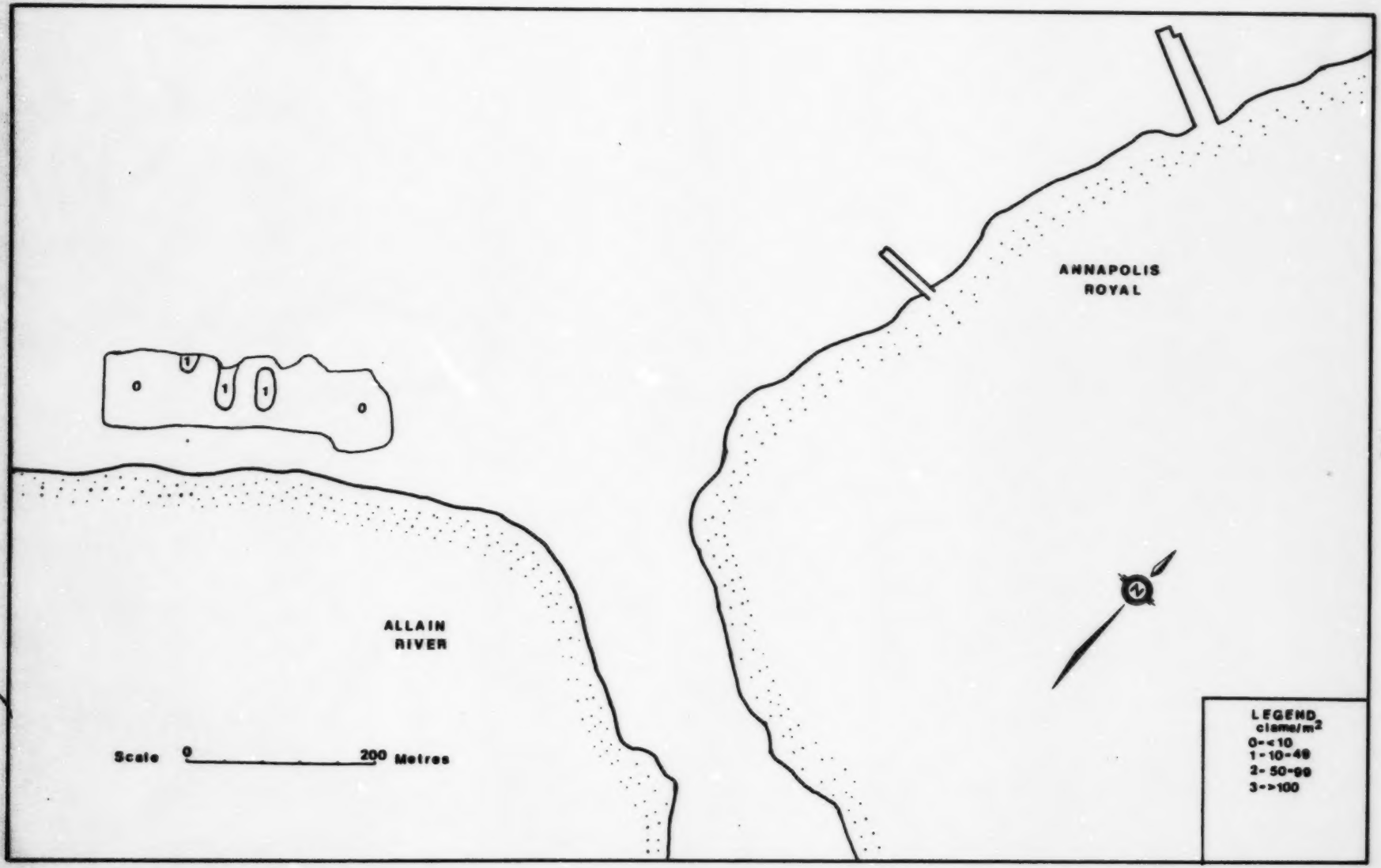


Fig. 37. Annapolis Royal Area "A" isopleths of clam density distribution - recruits.

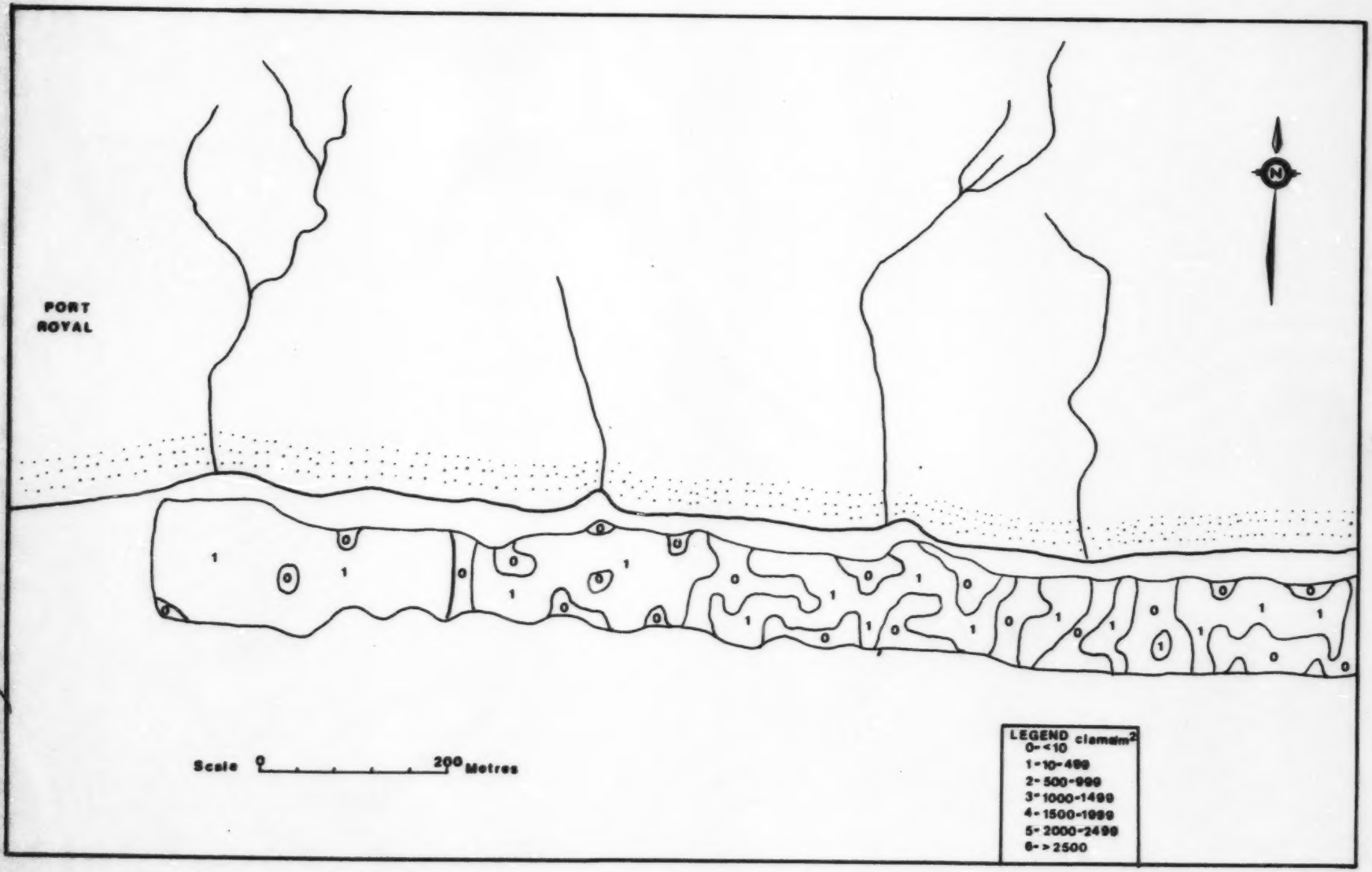


Fig. 38. Port Royal Area "B1" isopleths of clam density distribution - early recruits.

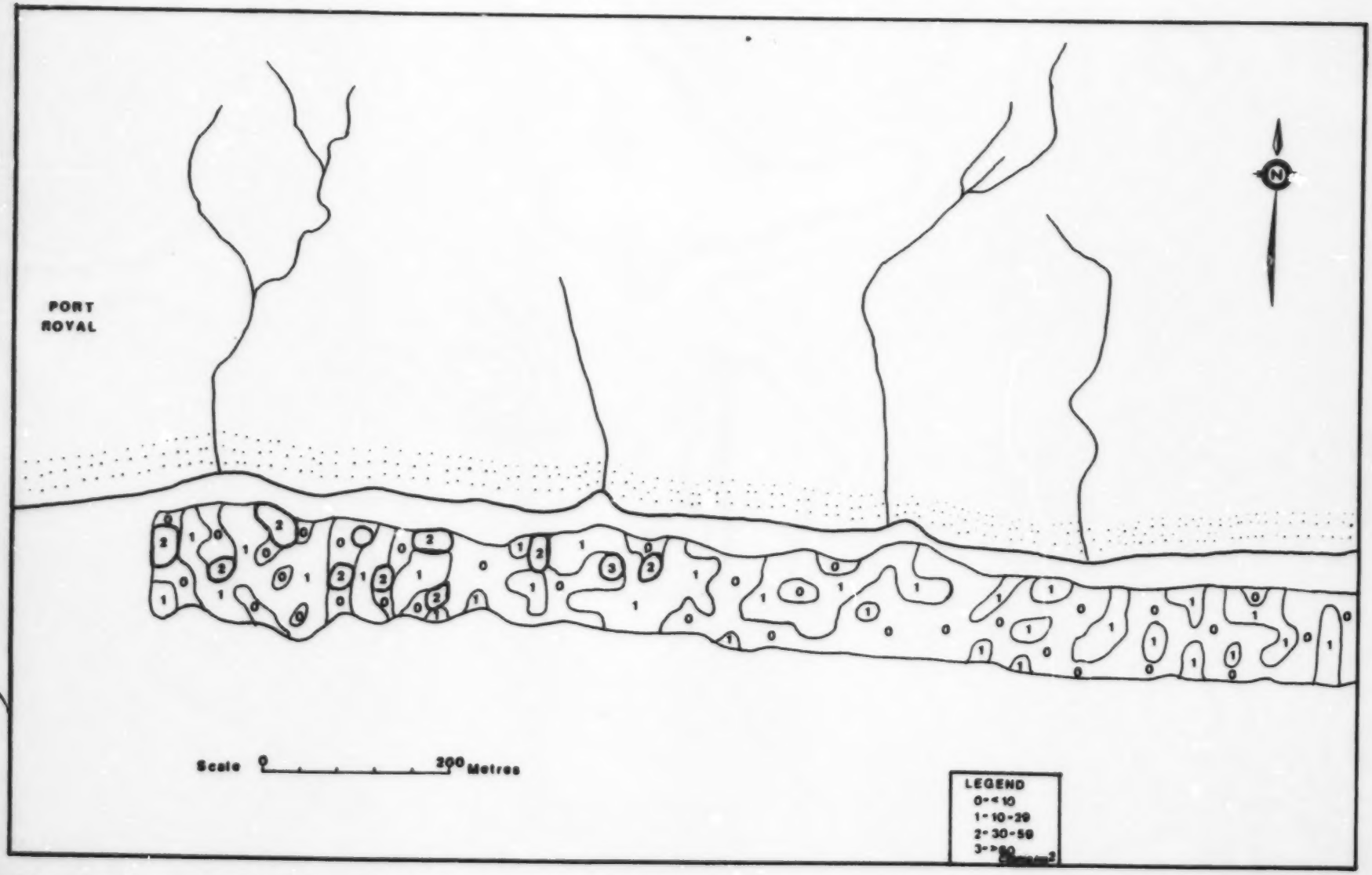


Fig. 39. Port Royal Area "B1" isopleths of clam density distribution - pre-recruits.

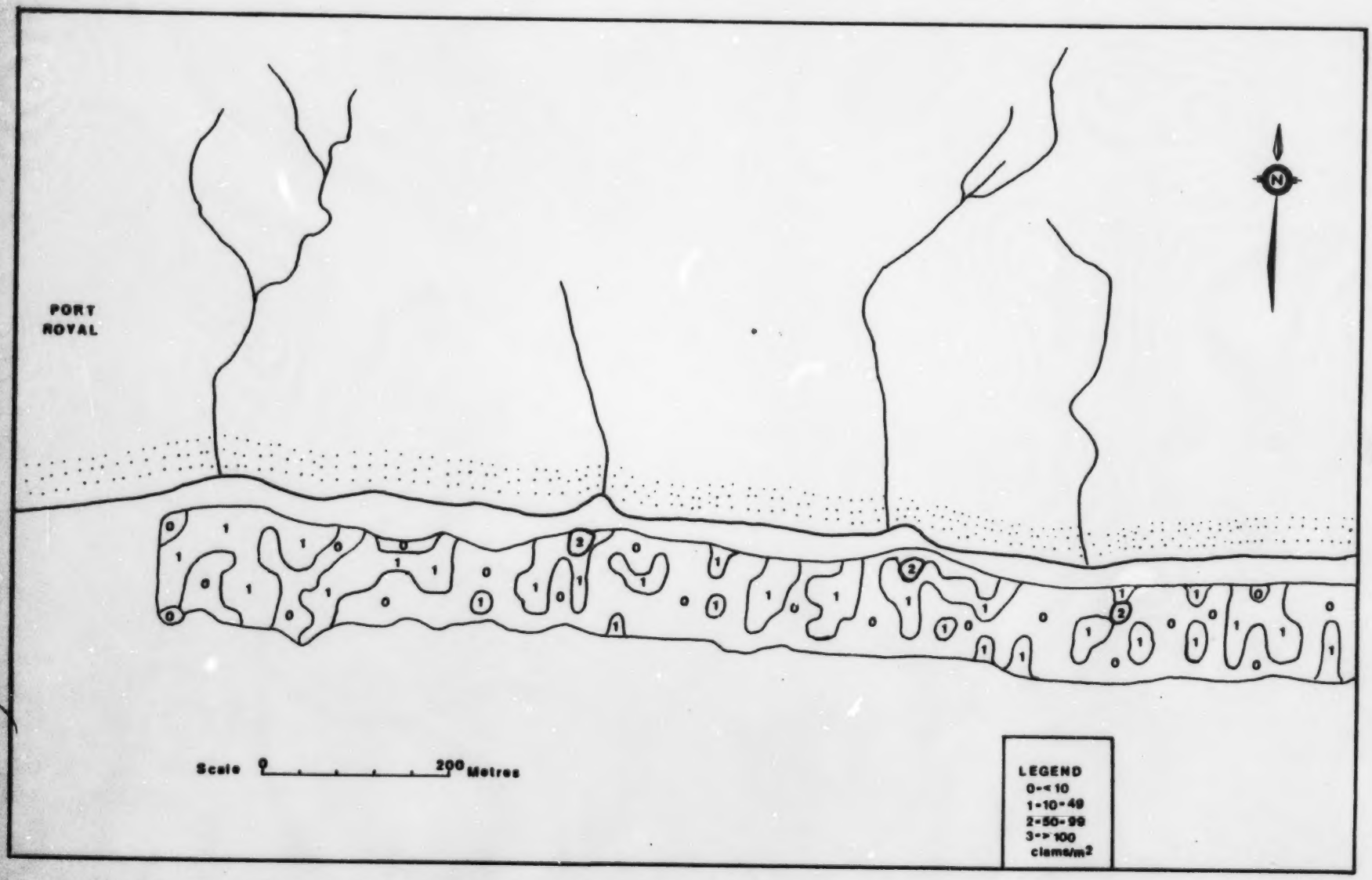


Fig. 40. Port Royal Area "B1" isopleths of clam density distribution - recruits.

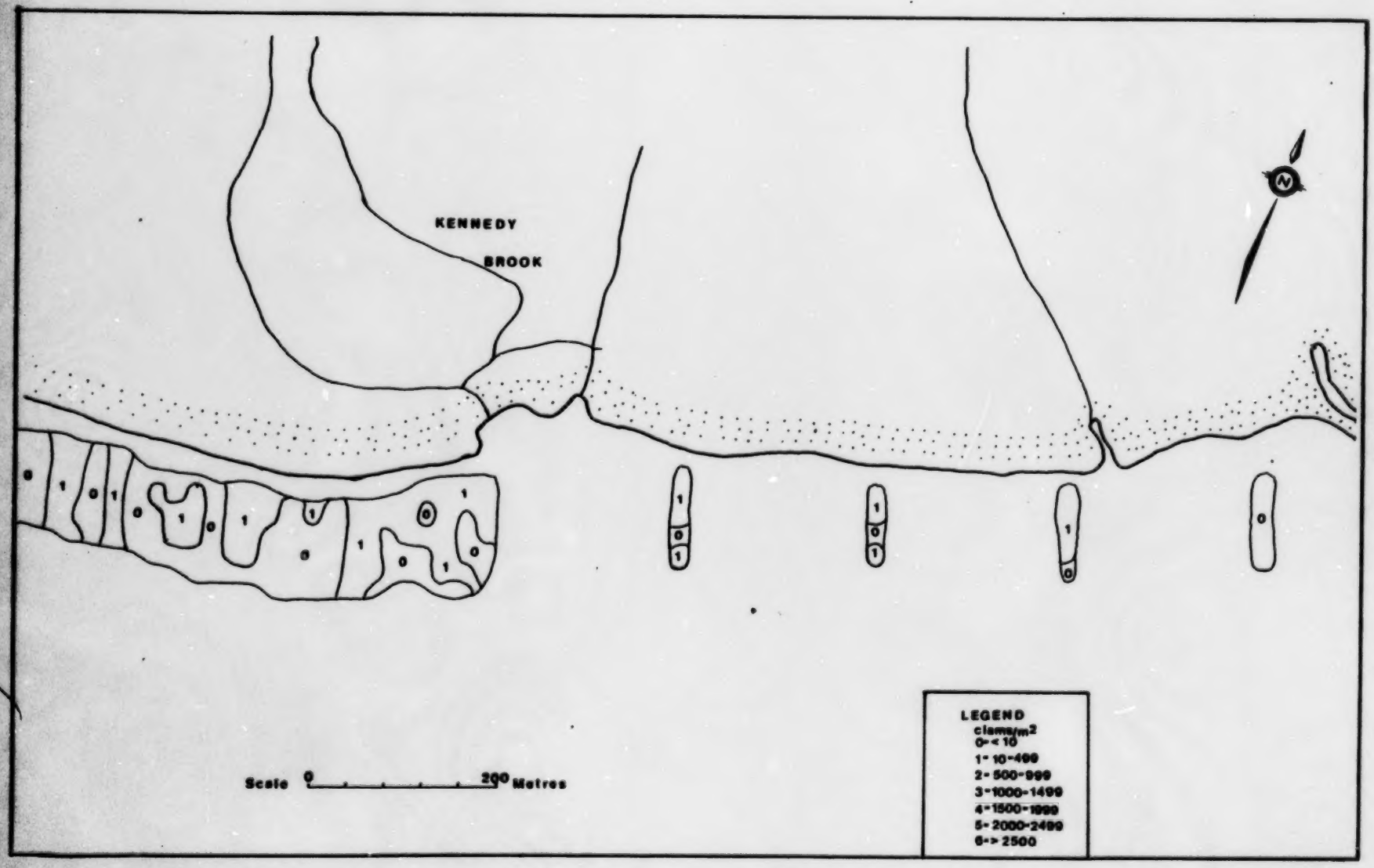


Fig. 41. Kennedy Brook Area "B1"/"B2" isopleths of clam density distribution - early recruits.

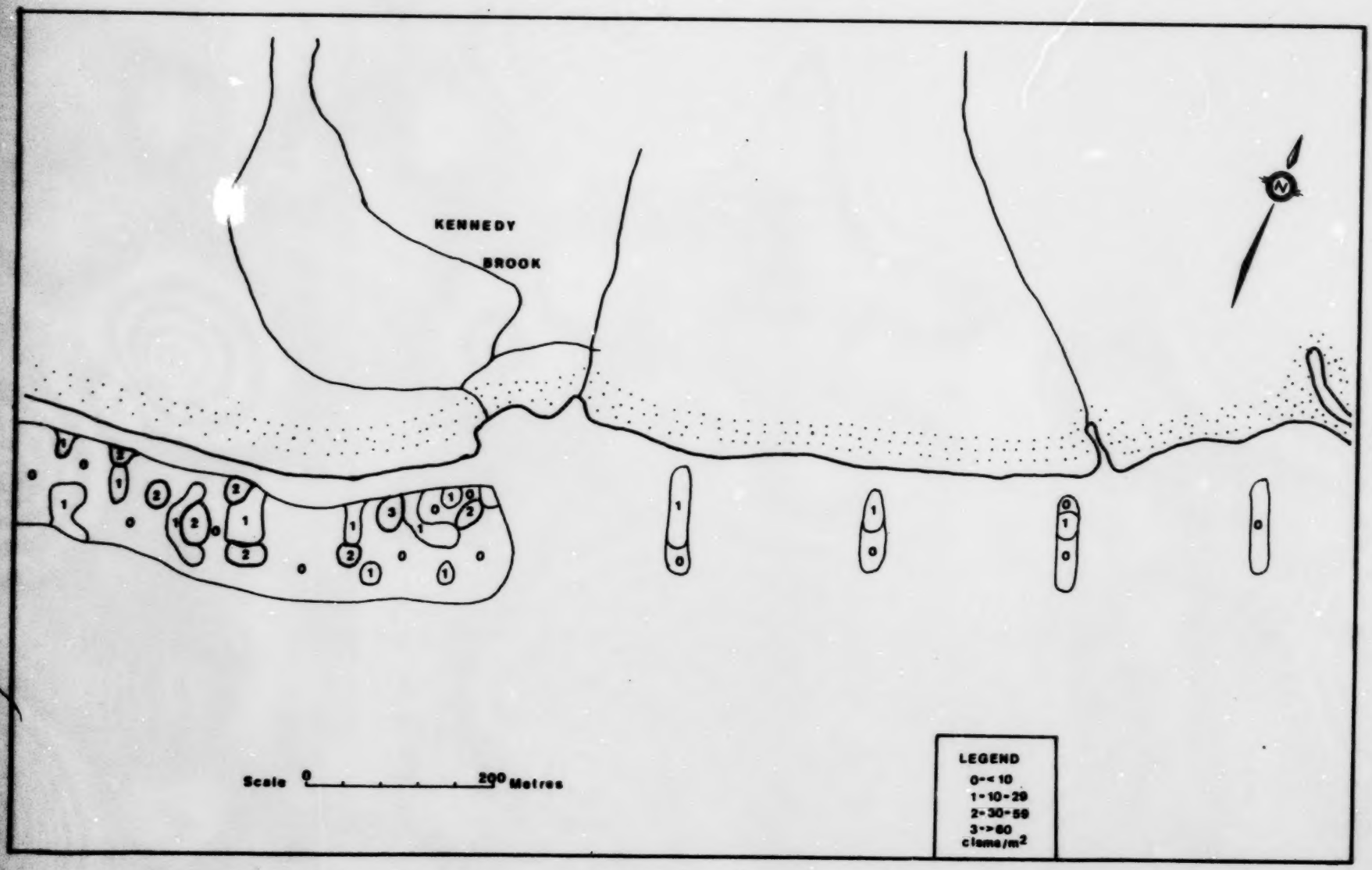
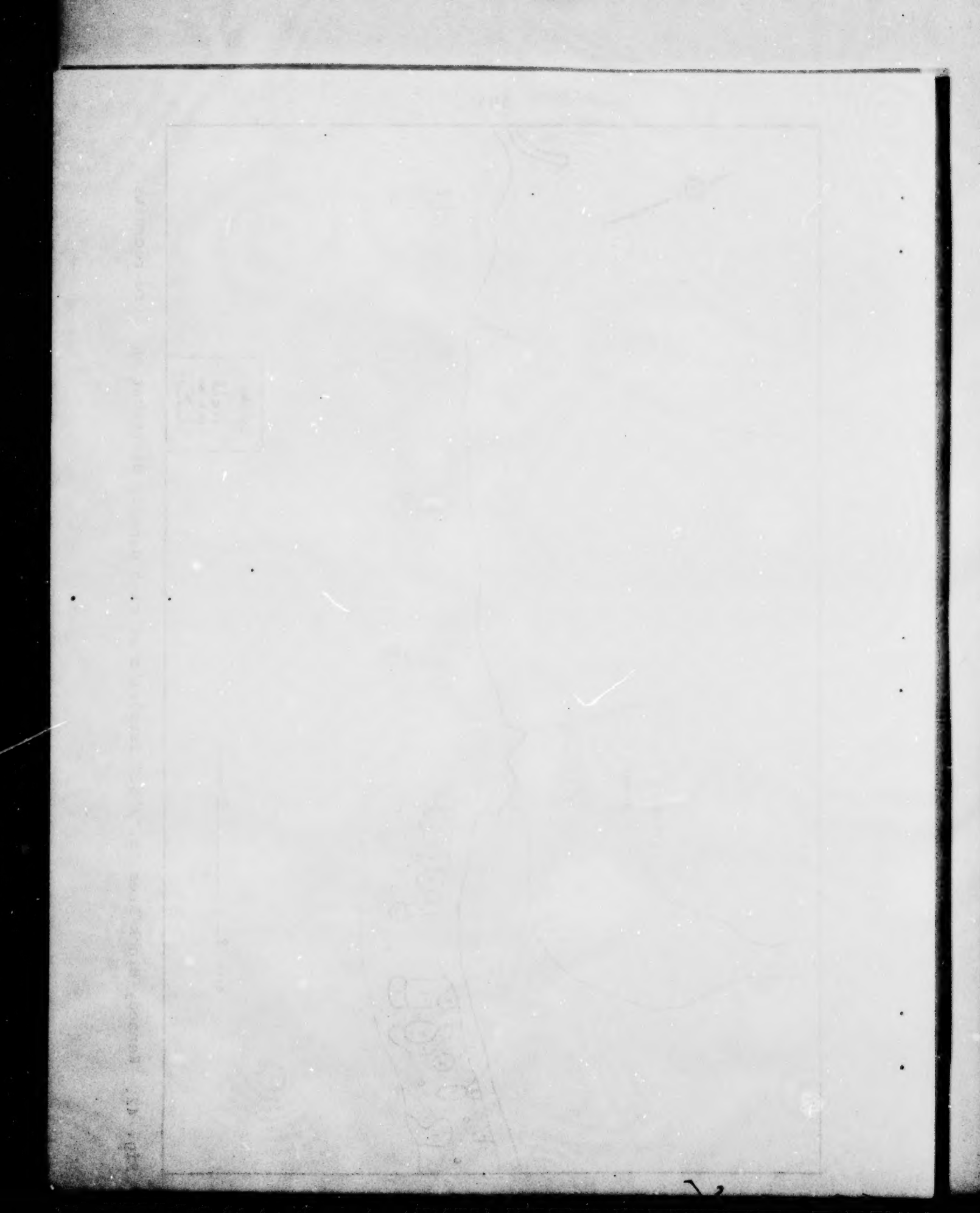


Fig. 42. Kennedy Brook Area "B1"/"B2" isopleths of clam density distribution - pre-recruits.



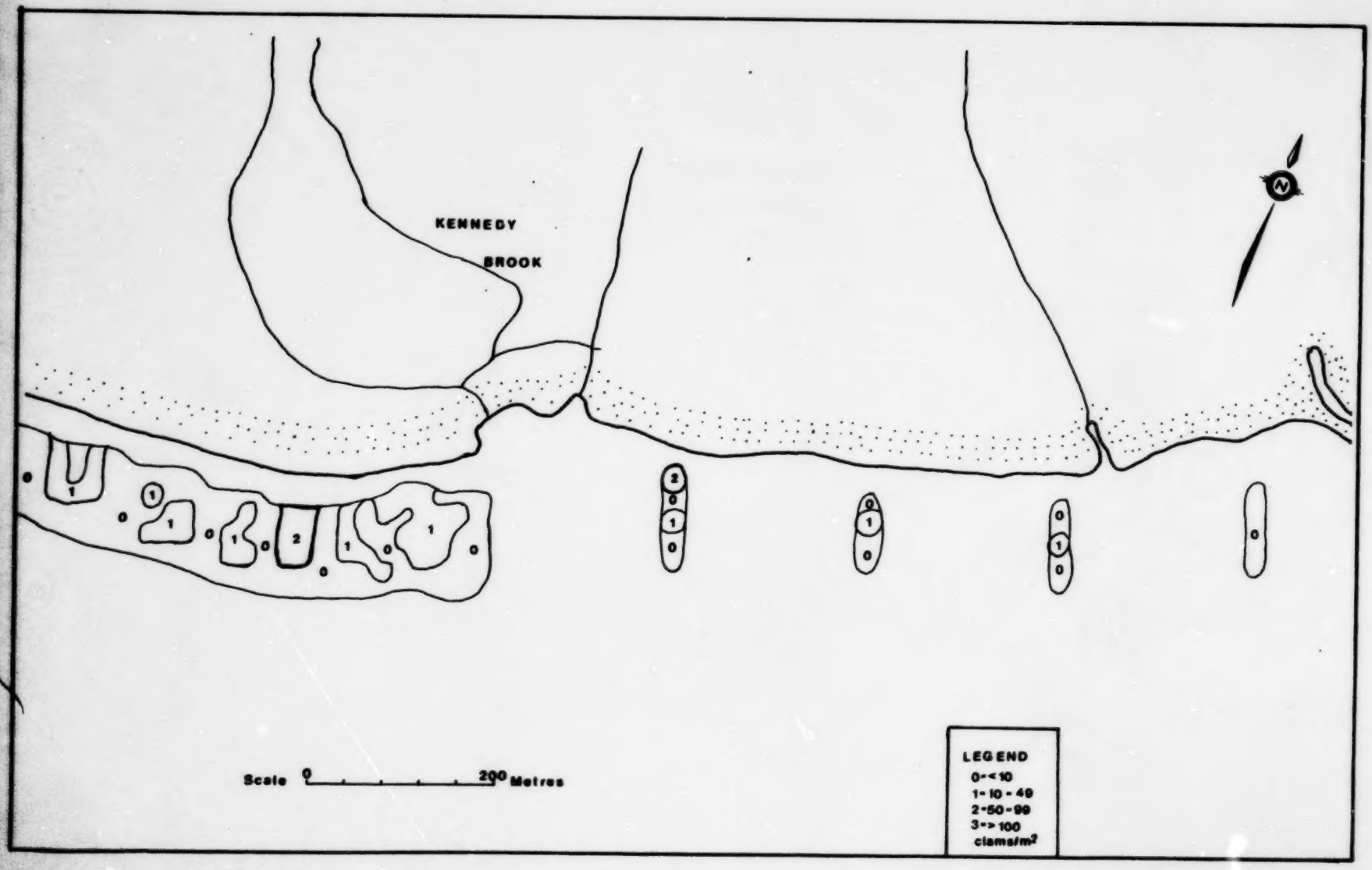


Fig. 43. Kennedy Brook Area "B1"/"B2" isopleths of clam density distribution - recruits.

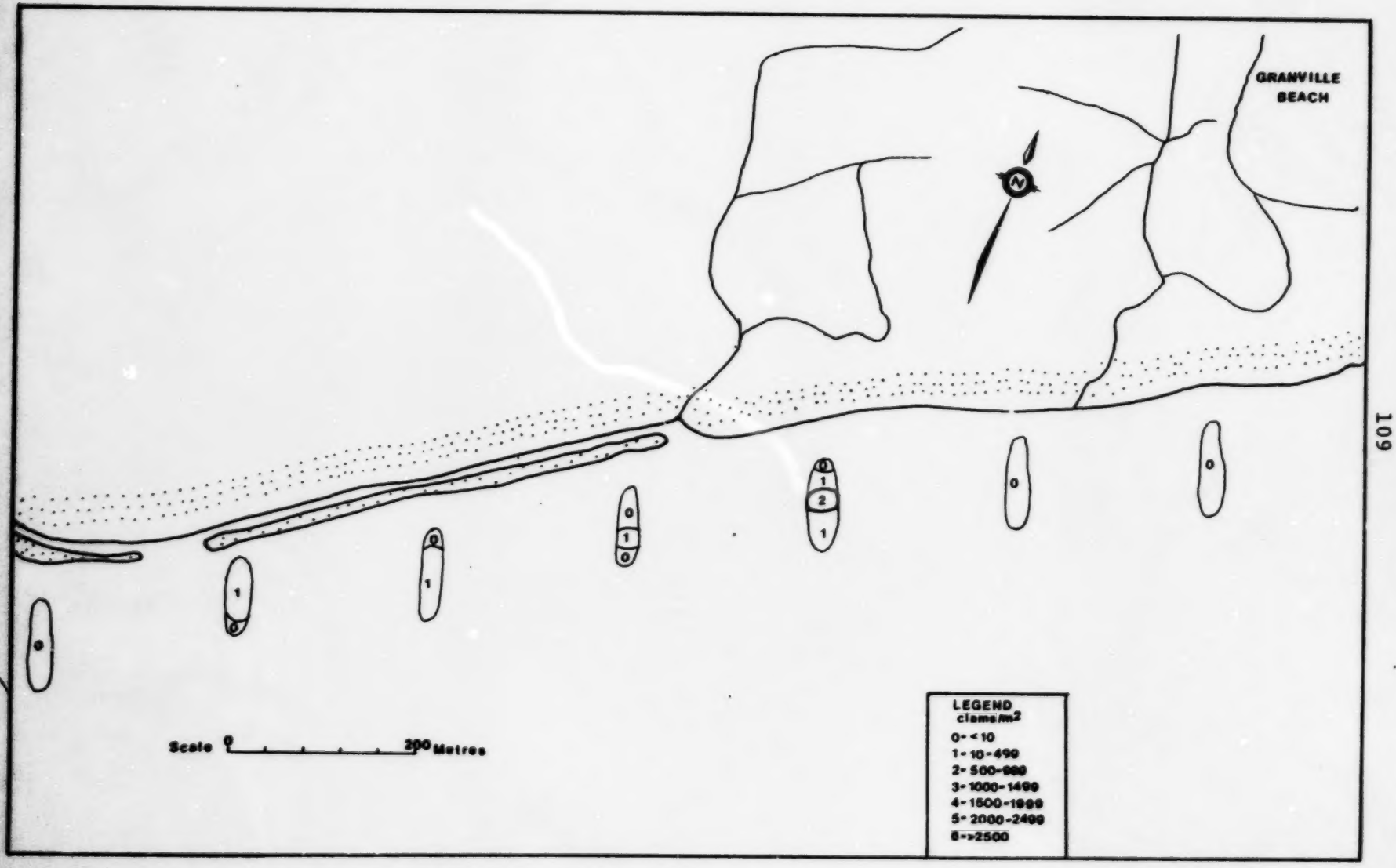
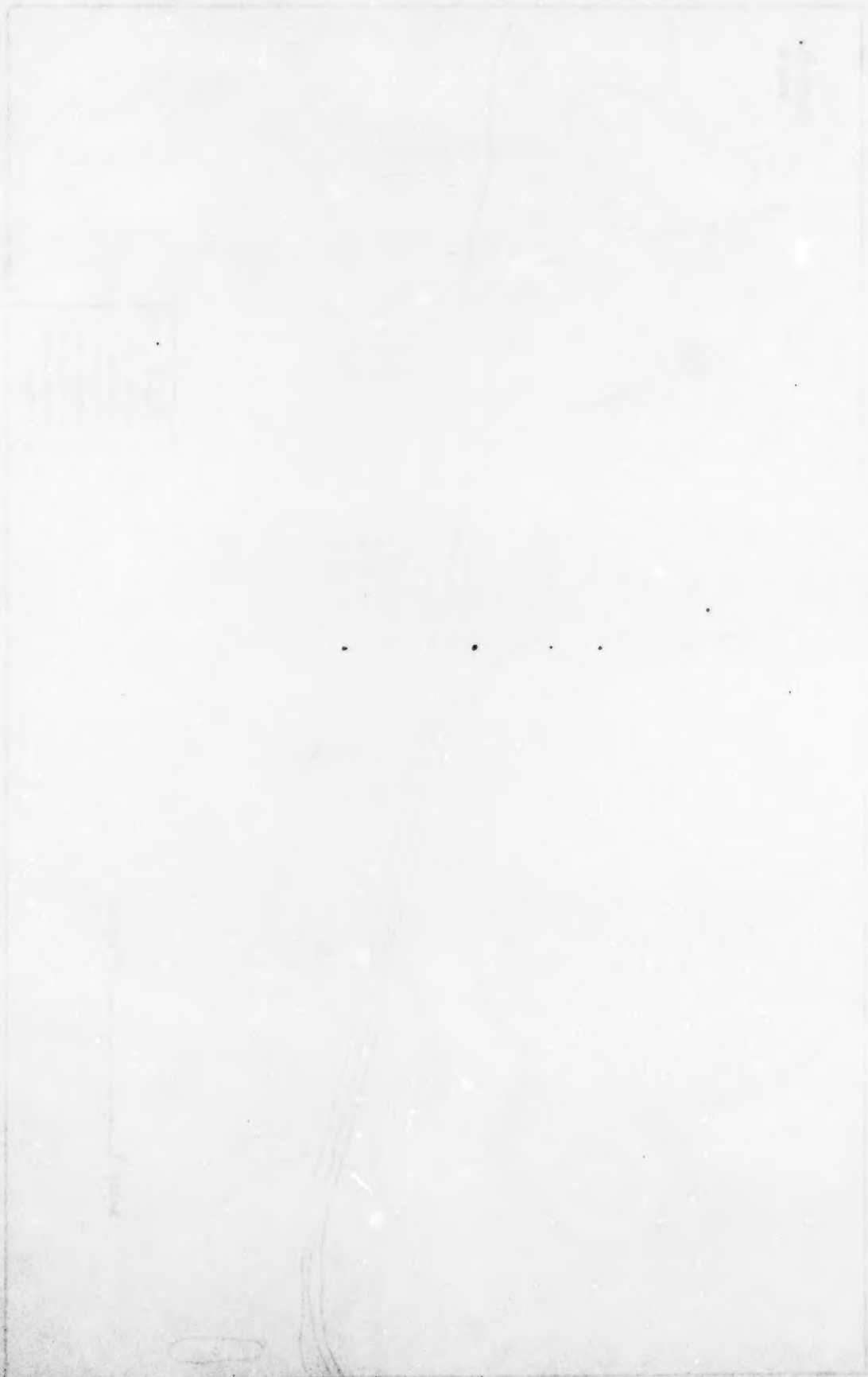


Fig. 44. Granville Beach Area "B2" isopleths of clam density distribution - early recruits.



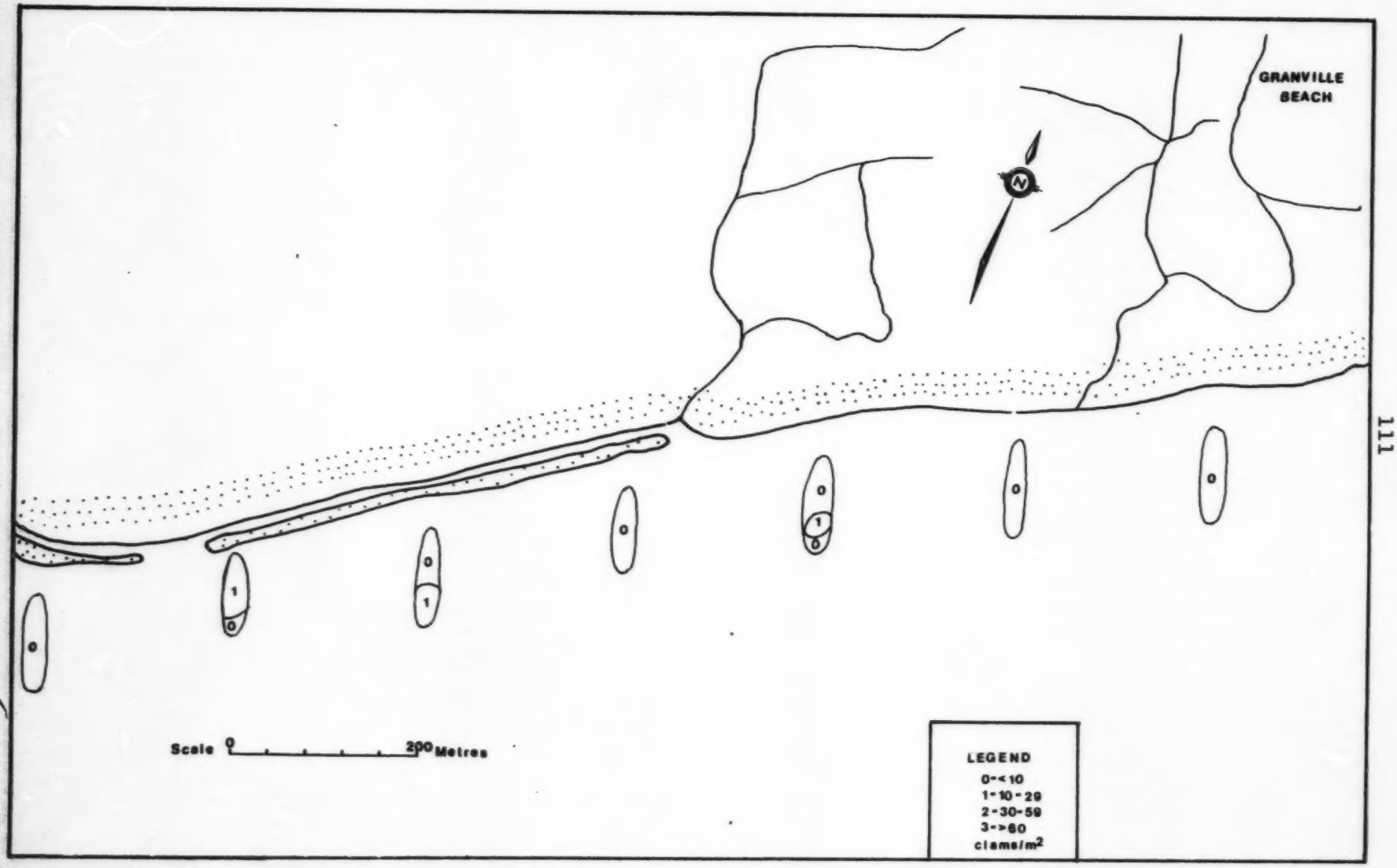


Fig. 45. Granville Beach Area "B2" isopleths of clam density distribution - pre-recruits.

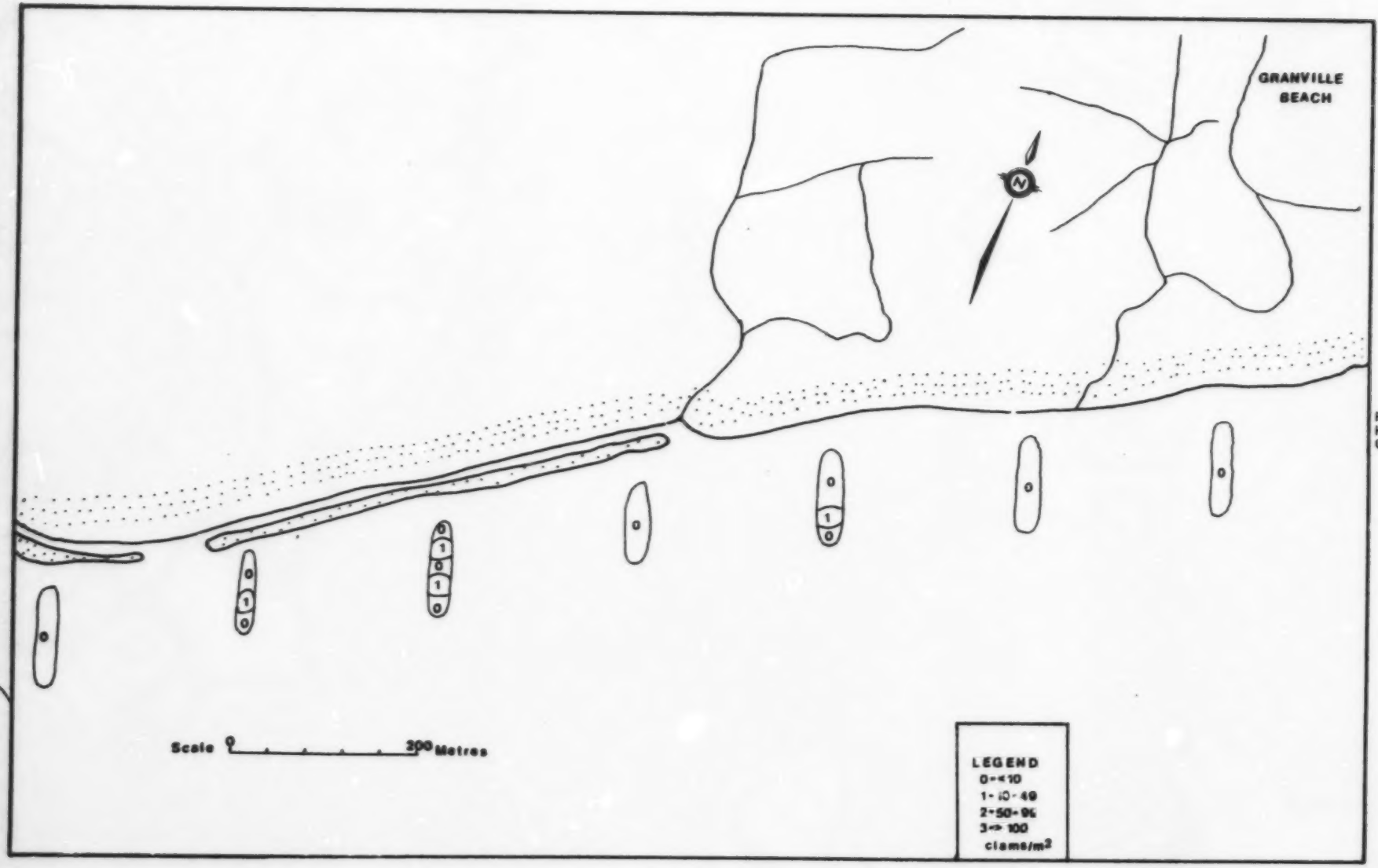


Fig. 46. Granville Beach Area "B2" isopleths of clam density distribution - recruits.

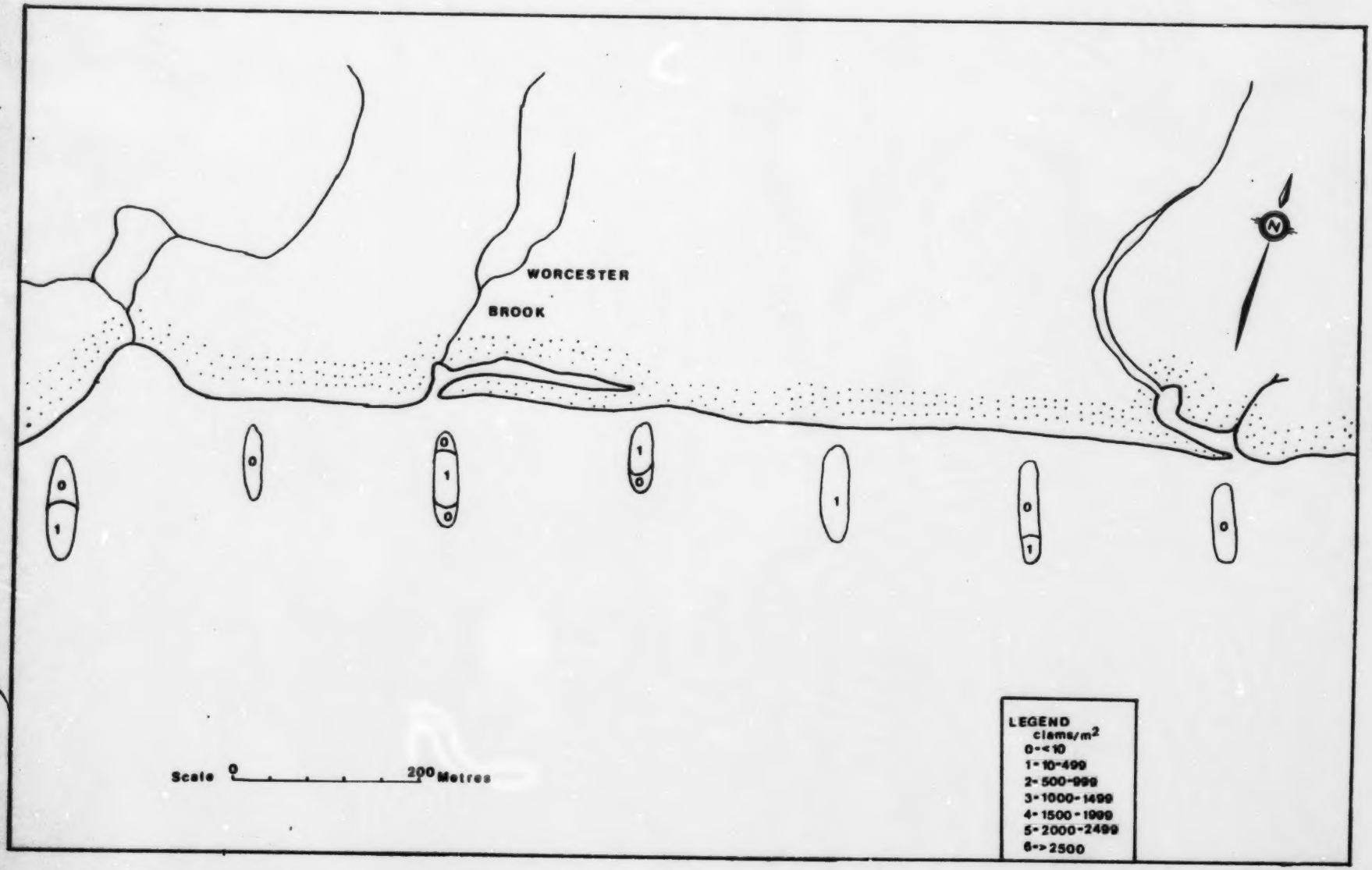


Fig. 47. Worcester Brook Area "B2" isopleths of clam density distribution - early recruits.

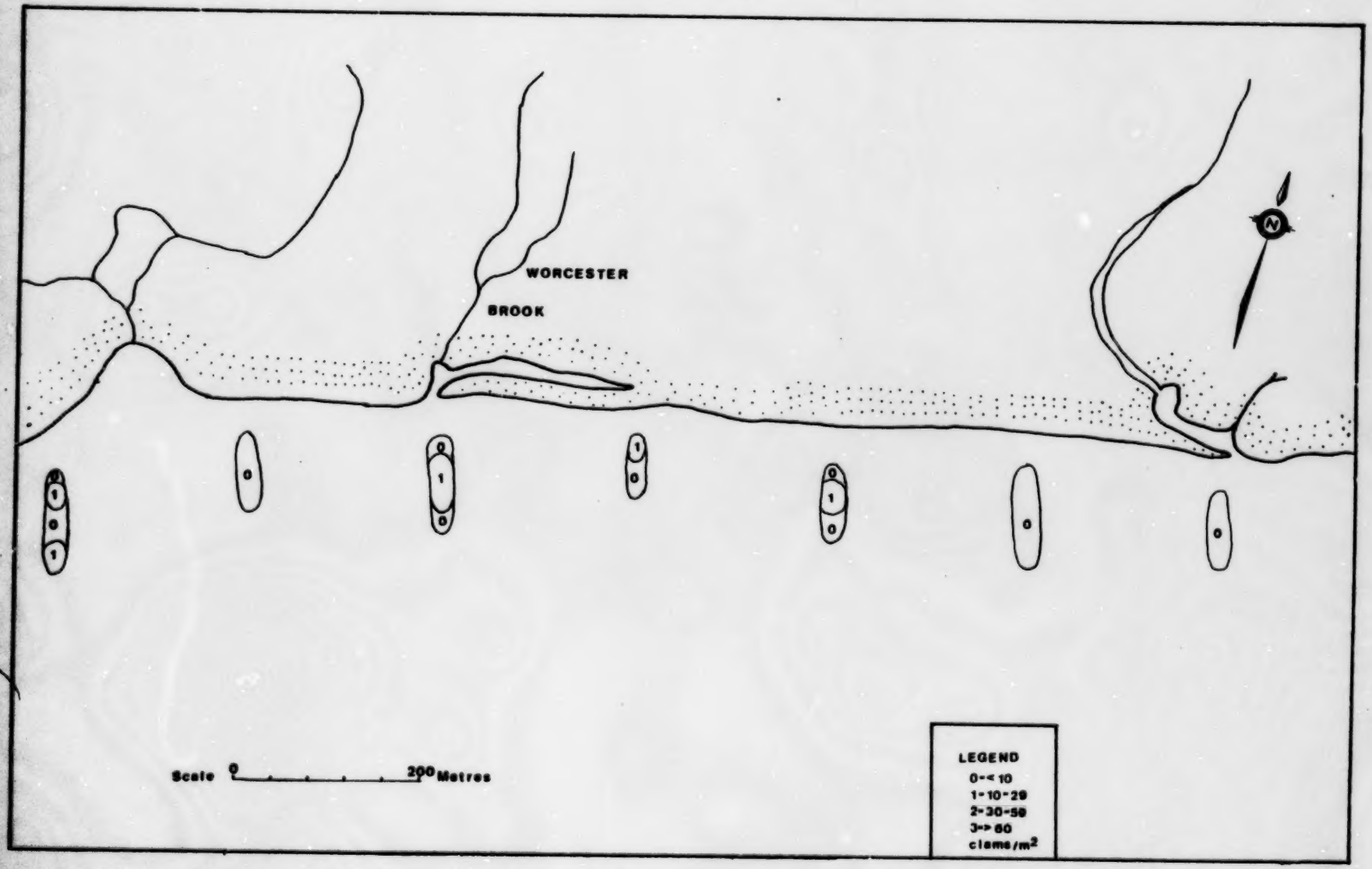


Fig. 48. Worcester Brook Area "B2" isopleths of clam density distribution - pre-recruits.

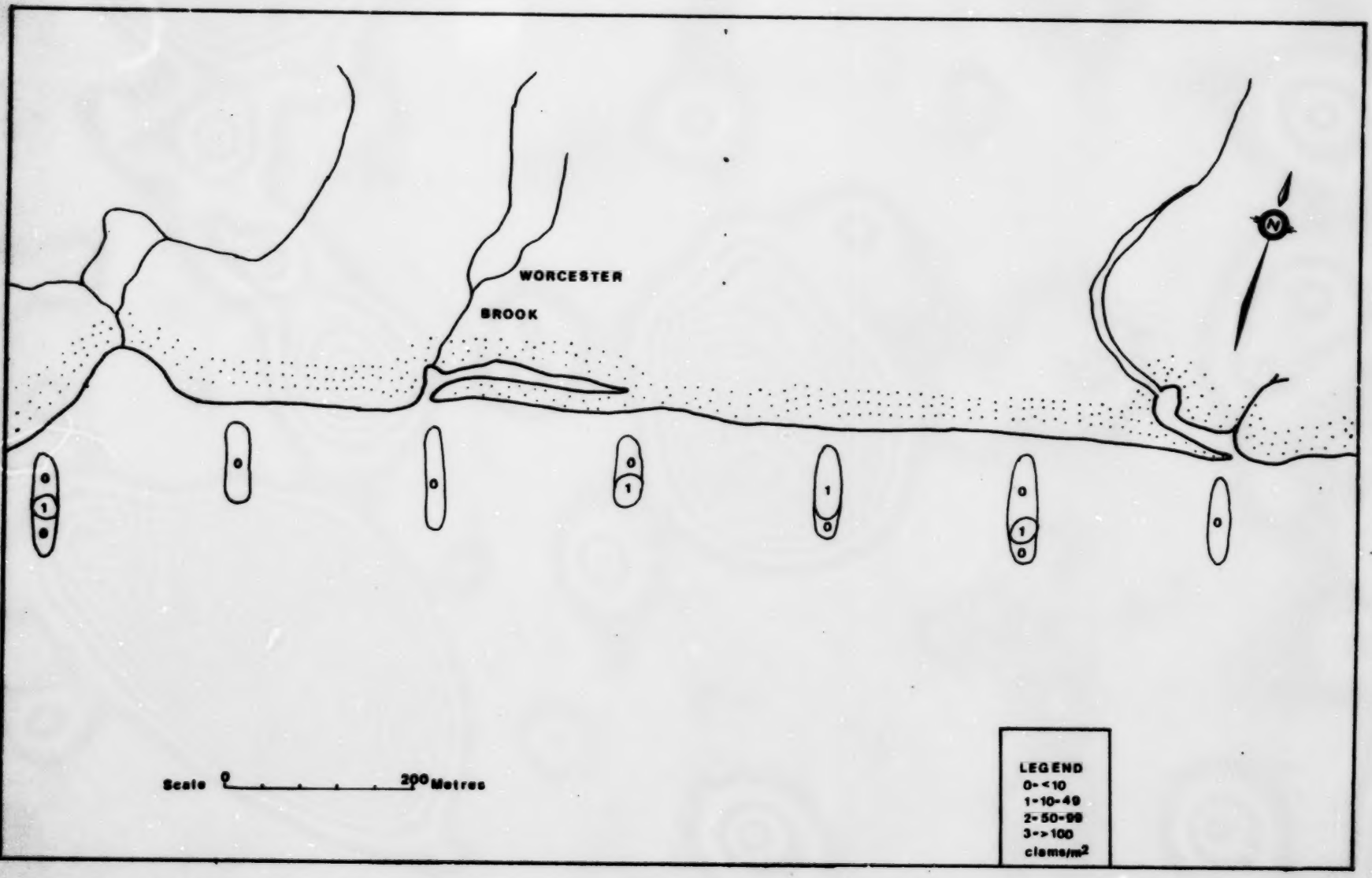


Fig. 49. Worcester Brook Area "B2" isopleths of clam density distribution - recruits.

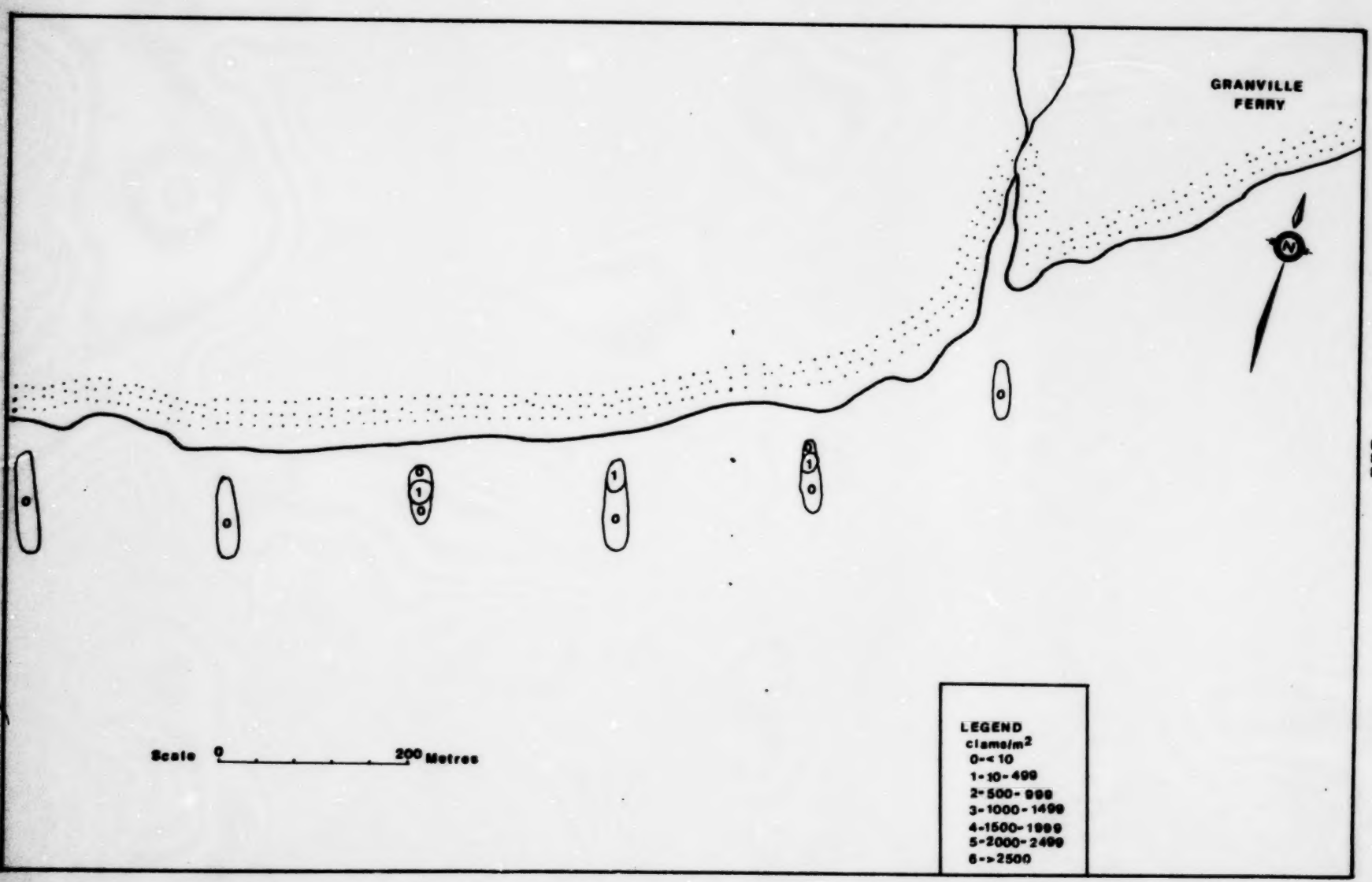


Fig. 50. Granville Ferry Area "B2" isopleths of clam density distribution - early recruits.

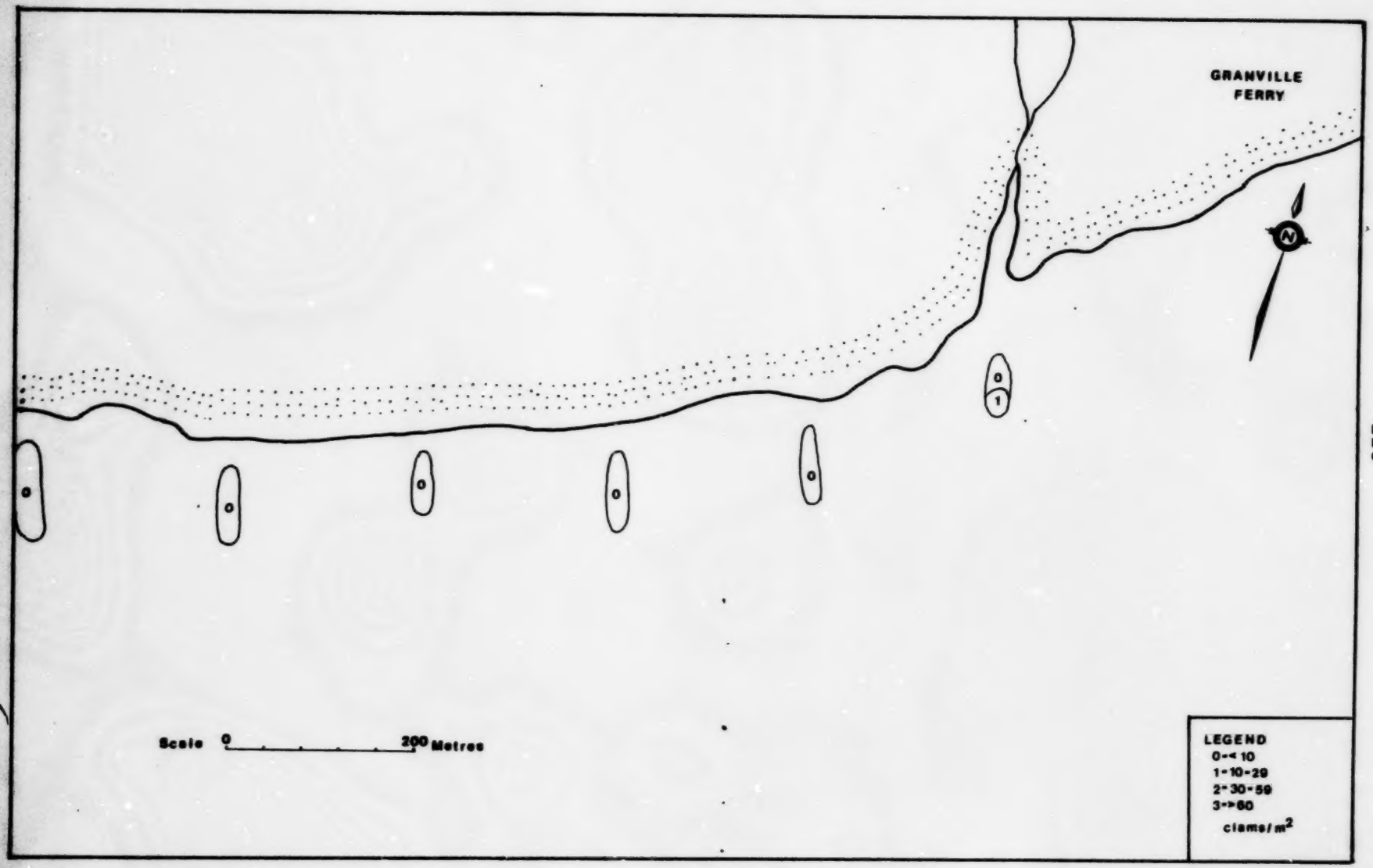


Fig. 51. Granville Ferry Area "B2" isopleths of clam density distribution - pre-recruits.

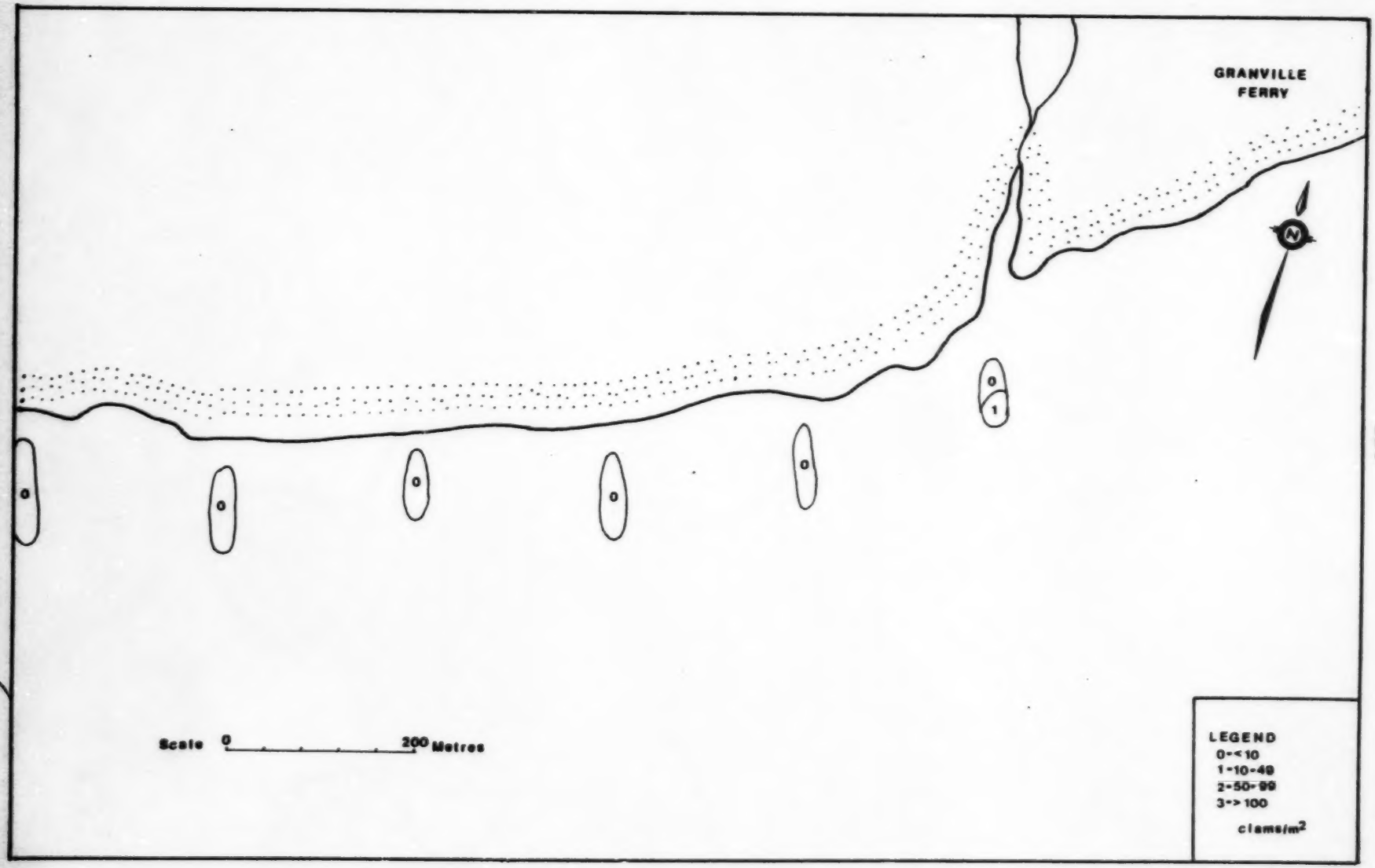


Fig. 52. Granville Ferry Area "B2" isopleths of clam density distribution - recruits.

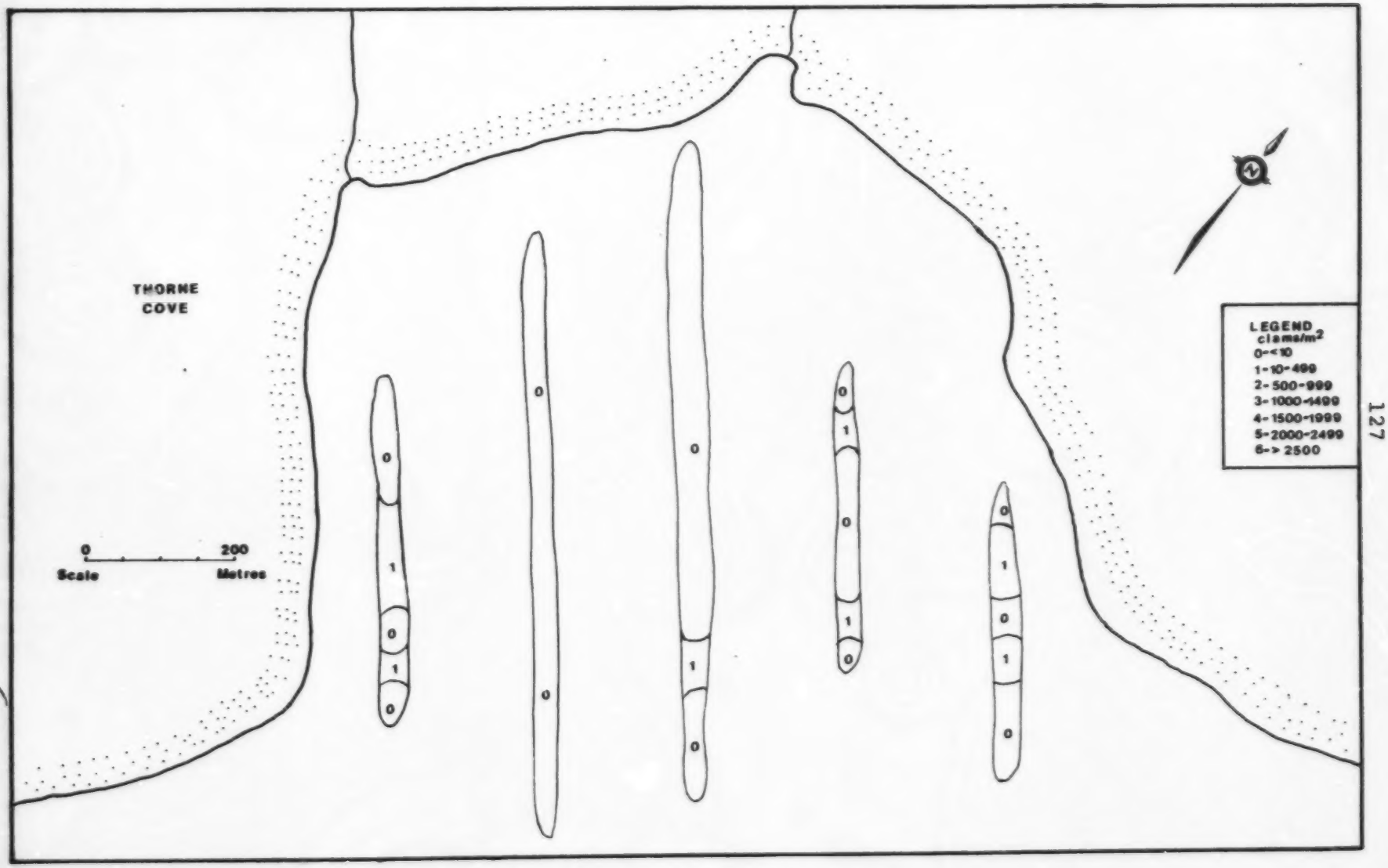


Fig. 53. Thorne Cove isopleths of clam density distribution - early recruits.

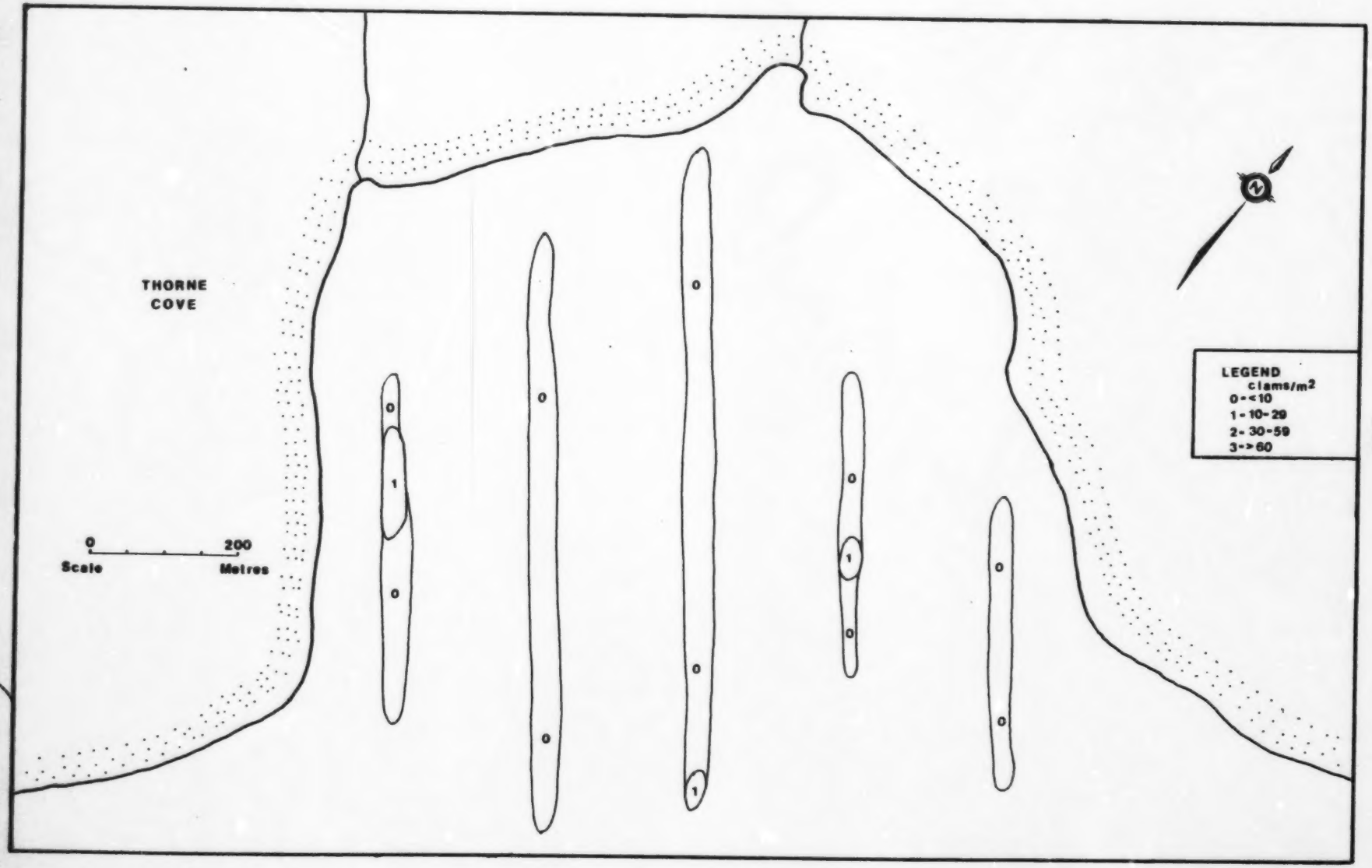


Fig. 54. Thorne Cove isopleths of clam density distribution - pre-recruits.

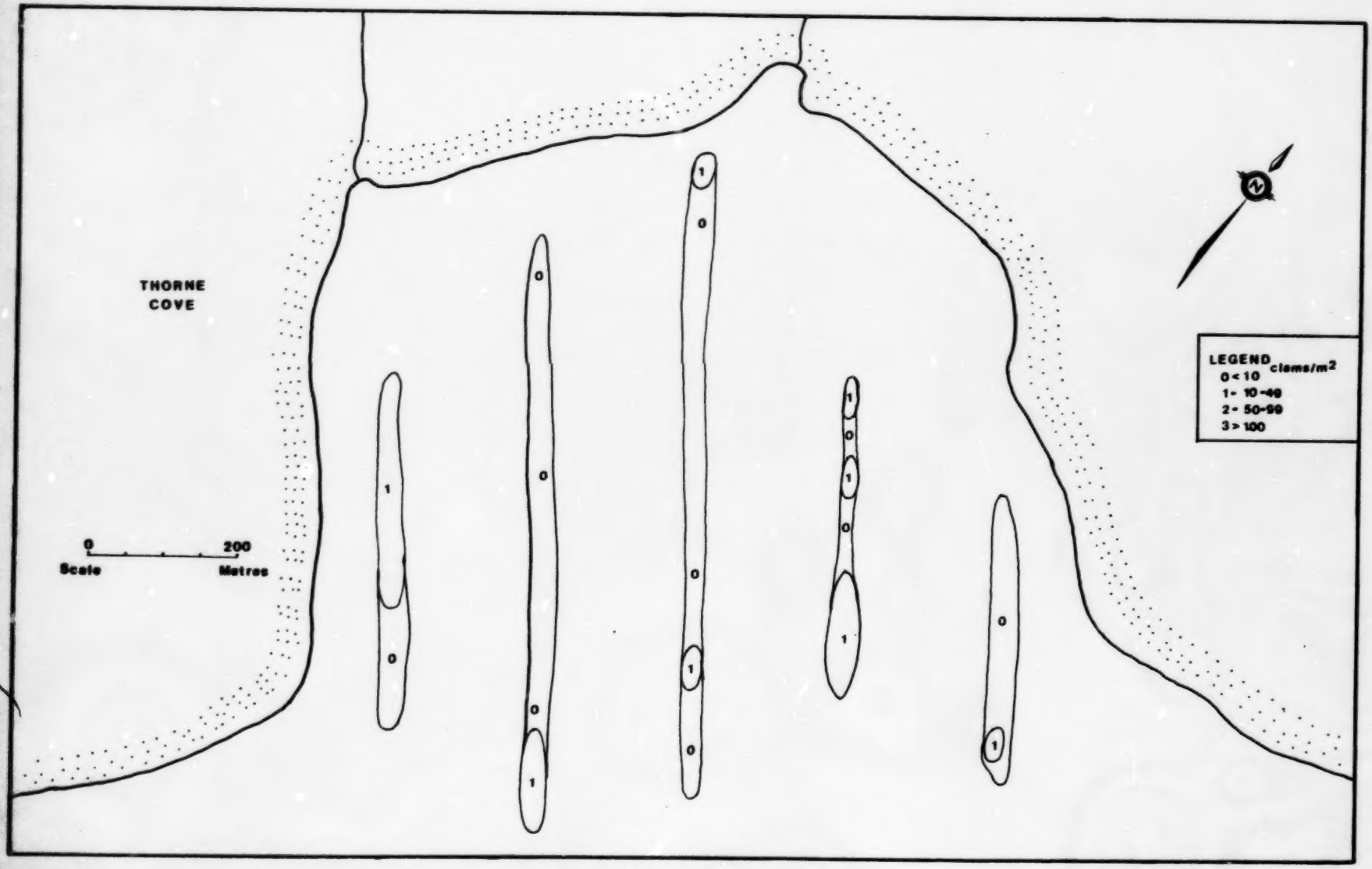


Fig. 55. Thorne Cove isopleths of clam density distribution - recruits.

Appendix. Data used in calculating the relationship[1] between clam length (in millimeters) and total number of clams in one bushel.

Size range (mm)	Clams/bushel[2]	Size range midpoint
0-20	23,815	15[3]
21-30	13,862	25
31-40	5,405	35
41-50	2,545	45
51-60	1,481	55
61-70	851	65
71-80	555	75

[1]Relationship: $y = a + b \ln x$

$y = 167.78 - 15.23 \ln x$, $r^2 = 0.95$, $n = 7$

where y = clams per bushel; and
x = clam length in millimeters.

[2]Number of clams counted to occupy a bushel.

[3]15 mm was selected as a midpoint in this range since there were very few clams of less than 10 mm.